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Manganese Ore in Cupola Practice

Elsewhere we print an interesting contribution, by Mr. B. Ramaseshiah, to the study of replacing ferro-manganese by manganese ore in cupola practice. A saving of the order of 4s. 6d. a ton is claimed for the conditions existing at the Mysore Iron and Steel Works. According to some rough calculations we have made on basic prices, the proposition is even more worthwhile in this country than in India, as apparently here manganese ore is very little dearer, whilst ferro-manganese is much more expensive, being about £19 as against £17 16s. per ton. Yet we can only consider Mr. Ramaseshiah's experiments as an *hors d'œuvre*, and he will leave his readers with an appetite for more solid meat. For instance, the reduction of manganese from manganese ore requires contact with solid carbon, the well-known gas reactions of the iron-producing blast furnace not being applicable. Thus it is germane to ask how much extra coke is required. As a second consideration, it is well known that the use of pyrolusite (manganese dioxide) in cupola charges was at one time common practice, but not for the purpose of increasing manganese. The sole object was sulphur reduction. These two statements seem to be borne out by reference to the author's results, for when he used lumpy manganese ore, little reduction was effected, but when soda ash was incorporated, it left the manganese free from its natural reaction of combining with the sulphur and so passing into the slag, in order to augment the manganese content of the iron. Much the same remark applies to his experiment incorporating limestone powder. Another question is the effect of the manganese ore additions on the rate and regularity of output, and the effect on the lining of the furnace. The second consideration is of the utmost importance, as excessive scouring of the lining not only brings about increased consumption of refractories for patching, but extra hours of labour are involved.

The influence of the process on the mechanical properties of the iron is a matter for speculation. Anticipating a pronounced sulphur reduction, one could logically assume from the research results of Colbeck and Evans in this country and Evans (G. S.) in America, that beneficial results would follow automatically. Yet by thinking around a proposition of effecting economies by using iron ore instead of pig-iron or scrap for the purpose of employing, *ab initio*, the cheapest form of iron per unit of weight, it immediately becomes apparent that, from a metallurgical point of view, there would be a serious lowering of quality. However, to state the obvious, manganese is not iron, and though on paper the reactions for the reduction from the ore look somewhat akin, there may be no deleterious results in making the cupola do some of the work normally effected in a blast furnace, whilst there are some grounds for anticipating an amelioration.

Inventions

Mr. Archibald Allison is reported to have opened his very interesting lecture on chilled rolls to the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen by stating: "So far as can be ascertained, the manufacture of chilled rolls is the only example of a process originating in one country and spreading thence to other areas." Dismissing all other considerations than metallurgical ones, we should have thought that origination at one place and subsequent spreading to other countries was more common, rather than the rarity. Whilst doubt may be justifiable in the case of the crucible furnace, the cupola, dry-sand moulding and many other phases, surely the history of the Bessemer process, the various discoveries of the regenerative open-hearth melting processes, and the fundamental phases of rolling-mill practice are sufficiently well known to state a cast-iron case for "a process originating in one country and spreading thence to other areas." It is probably because of the large number of inventions of which the origin is doubtful, due to simultaneous discovery or, better worded, "independent discovery" in lands far apart, that the opposite view is held. Quite often the question of invention and its origin is complicated by the inability of the discoverer to perfect his process owing to the inadequacy of auxiliary machinery at the time of the invention, lack of capital or sustained interest. It obviously must have occurred to foundrymen many generations ago that cores could be eliminated by centrifugal casting, but the mechanical appliances necessary to effect this would still have to be invented. Set-backs due to lack of capital are often referred to in the biographies of great inventors, whilst lack of sustained interest must be the cause of allowing certain inventions to lapse. In collaboration with Mr. Victor Stobie, we once discovered a veritable master patent which anticipated many of the best-known systems of electric arc furnaces, and later we learnt, when visiting the works of the inventor, that Bertolus, the gentleman in question, was more interested in actual manufacturing than the exploitation of patents! The origin of the

(*Concluded on page* 362.)

Increase in Spelter Duty

By "ONLOOKER."

It was in March, 1932, following the Ottawa Conference, that a 10 per cent. *ad valorem* duty was imposed on imported foreign lead and spelter, it being understood by all concerned that the Empire producers, for whom in effect this market was reserved, would supply all the spelter and lead required at the world price, viz., the quotations on the London Metal Exchange. For some weeks prior to the date of imposition of the duty foreign lead and spelter had been pouring into this country, and in consequence of these adequate supplies of duty-free metal consumers suffered no immediate inconvenience. Before many months had passed, however, complaints from consumers that they were not getting their spelter at the world price began to circulate, and a certain amount of bad feeling was engendered. In explanation of apparent breach of the agreement it must be borne in mind that the quality of the metal supplied from Empire sources was definitely superior to that of the ordinary G.O.B. brands, which constitute a good delivery on the Metal Exchange. Some consumers, of course, did not require a quality better than G.O.B., and their hardship was certainly a very definite one and not easily satisfied in the circumstances.

Be this as it may, three years of this arrangement were sufficient to convince the producers that all was not well, and in 1935, on the joint representation of the consumers, suppliers and Metal Exchange, *ad valorem* duties were rescinded and a flat rate adopted, 7s. 6d. on lead and 12s. 6d. on spelter. At the same time it was enacted that the Dominion producers should be allowed to add to the L.M.E. price a "permitted premium" equal to the duty, the idea being that by this means, and the clausing of the Metal Exchange contract accordingly, business would be attracted to Whittington Avenue, and the downward thrust exercised by hedging sales offset to a great extent through the support afforded by purchases made by consumers and merchants. Matters have not worked out in this way, and producers have continued to sell direct to users, while the bulk of the sales on the market have been for account of foreign interests, the metal being shipped for lodgement in bonded warehouses in this country. Now, apparently, this evil is to be intensified by putting the duty even higher than it has been, the net result of which can hardly fail to be intensification of the downward pressure against the London market, unless some watertight arrangement among producers for limiting output can be reached. With a bargaining counter in the shape of a 30s. duty to help them, the Empire producers may well succeed, partially at any rate, in such an endeavour.

Home Production

Since its inception the spelter tariff has not been much of a success as a revenue raiser, but this, of course, was not the intention; its *raison d'être* was in fact the desire to see this country drawing upon the Empire for its supplies of zinc, and in this it has certainly been successful, for imports from the Dominions have greatly increased. Now, however, there is another aspect, and that is the preservation of a spelter-producing industry in this country. To this end the new scheme provides for payment to the Imperial Smelting Corporation of a levy at the rate of 10s. per ton on spelter imported from the Empire, and the company will also benefit from the 30s. "permitted premium" on its own sales. Apart from a plan to hand over to the consumers a sum of money as a subsidy for their export trade, the users of spelter appear to have been completely overlooked in this matter.

The Late Mr. Sydney Gimson

We sincerely regret to announce the death of Mr. Sydney Gimson, which occurred at his home, 20, Glebe Street, Leicester. Mr. Gimson, who was 78 years old, was President of the British Foundrymen's Association (now the Institute of British Foundrymen) at the outbreak of the war, and he remained in office until 1915, when he was succeeded by the late Mr. J. Ellis. He was the third son of Mr. Josiah Gimson and received his education at Stoneygate school. In 1872 he joined the family business of Gimson & Company, engineers and ironfounders, was a partner in 1885 and a director in 1896. He retired in 1909 at the age of 49 to devote his activities to public affairs. He was elected to the Town Council, where he took a special interest in technical education, serving on Technical and Art Committees. His special interest throughout his life, and one which he inherited from his father, was the Leicester Secular Society—a body over which he presided for half a century. It was his special request that there should be no theological ceremony at his funeral. During the war he presided over the Leicester Belgian Refugees' Committee and his great devotion to this work is still remembered with affection by the many hundreds of exiles who came under his care. As a Justice of the Peace, his special interest was the humanitarian side of the Juvenile Court.

MR. S. GIMSON.

Members of the Institute of British Foundrymen cherish pleasurable memories of the kindly reception he accorded to them during the period of the 1913 and 1928 Conventions at the famous cottage he built with local rock on the Chitterman Hills, between Ulverscroft and Monkfield. On the former occasion he had at his side the late Mrs. Gimson, wearing a white poke sun bonnet, and between them they diffused a real old-world atmosphere. Older members still affectionately refer to them as Derby and Joan, but this happy partnership was ended when Mrs. Gimson died in 1923.

Mr. Gimson's main interest in the Institute was its educational potentialities, and he confessed that he never took an active part in the practical or technical side of foundry practice, to which he had not served an apprenticeship, in fact, he put this forward as a reason for disqualifying him from adequate occupancy of the chair. Mr. Gimson leaves two sons, Mr. Basil Gimson and Mr. Humphrey Gimson, and to them we extend the sincere condolences of the foundry industry, which has for so long a period held the name of their father in high esteem.

Inventions

(*Concluded from page* 361.)

invention of stainless steel of the high-chrome type has been made more intriguing than is usual by the sealed statement which Mr. Harry Brearley has deposited with the Cutlers' Company, and which is to be opened at some time in the distant future. The more one studies the origin of inventions, the more dangerous it appears to dogmatise, and we think that there are available authentic cases of simultaneous and widely spread independent discovery, and sole origination, coupled with instances which could be genuinely labelled "re-invention."

Random Shots

The other week in London the Newcomen Society met to hear Mr. Rhys Jenkins lecture on the history of ironfounding in England from 1490 to 1890. That period necessarily means a summary of the history of the Sussex wealden iron industry. Whilst one knows that there is abundant literature on that subject, yet it is refreshing to know there is a society especially devoted to studying the past rather than the present. In an age when Progress and Modernity are the gods most popularly worshipped, a society such as this "Newcomen Society for the Study of the History of Engineering and Technology" (what a mouthful!) stands out in pleasant relief. It has, "Marksman" was interested to learn, a branch in the United States.

* * *

It might be thought that there is a conspiracy in London at the moment to make one halt awhile in the general mad push forward: to stop and reflect on some of the beginnings of modern progress. The Edison Swan exhibition of historic electric lamps contains the first incandescent electric lamp made by Sir Joseph Swan in 1877, the first commercial electric lamp (1881), the first electric street lamp (1891) and the Fleming experimental valve (1883) which made present-day broadcasting possible.

* * *

Even the "Sunday Times" Book Fair at Earls Court has a corner devoted to historic documents and first editions, some of which are of great interest to scientists and to business men in general. There is, for instance, the very first Bradshaw railway guide, published in 1839, a book no bigger than the modern pocket diary. Now one understands why trains yearly strive to gain speed; it is necessary to counterbalance the extra time needed to struggle with the present-day Bradshaw! There is, too, a booklet entitled "Le Cinematographe"—a phenomenon shown for the first time in 1897 at the Empire Theatre in London. An account of the "Daimler (Horseless) Motor Company" in 1896 reminded "Marksman" with a shock how comparatively recently the horseless carriage was a novelty. "The shares of this company, formed only a few weeks ago," it reads, "were actually passing hands at 3d. each."

"MARKSMAN."

Coming to Town?

For many years, the provincial Branches of the Institute of British Foundrymen have on the occasions of their annual banquets and balls been well supported by visitors from the metropolitan area. This year, an opportunity occurs for members of the various sections to support the effort which the President (Mr. C. C. Booth, J.P.) and members of the London Branch are making to celebrate their twenty-first annual dinner. The principal guest is to be the Right Honourable Lord Meston, K.C.S.I. The venue chosen is the Criterion Restaurant, Piccadilly Circus, and the date is particularly suitable for those coming from the provinces—Friday, December 16. The tickets are 12s. 6d. each, and it is particularly desired that members bring their ladies.

Music is to be provided by George Ennes Hardy and his Band. At 11 o'clock there is to be a cabaret compèred by the well-known entertainer Mr. Stock Wynn; Miss Betty Millar and Mr. Milton Stanley are to be the main attraction. Invitations may be obtained by applying to the Secretary, Mr. G. W. Daglish, Stewarts and Lloyds, Limited, Winchester House, Old Broad Street, London, E.C.2.

Electric Furnaces in European Steelworks*

By DONALD F. CAMPBELL

The last few years have been a period of intense activity in the European steel trade, and, as a result, a large number of electric furnaces have been constructed.

Technical developments vary in different parts of Europe, owing to the divergence of the natural resources in different countries and their national policies of self-sufficiency. Recent developments in Europe include the construction of electric iron-ore smelting furnaces of new design in the few countries where exceptional circumstances make this method of reducing iron ores commercially possible. Improvement in detail of the electrical and mechanical design of steel-melting arc-furnace construction has also been rapid, and interesting new metallurgical practice has been developed. The increased use of high-frequency induction furnaces for making special steels has been remarkable and the size of individual units has increased.

Shaft furnaces, which have been used for the reduction of iron ores in Sweden for more than 30 years, are now being replaced by pit furnaces of comparatively simple design in which the rich gases are collected and used for general heating purposes. This type of furnace is especially suitable for smelting iron ore with coke, which is often available as a reducing agent where wood charcoal, which was used in the electric shaft furnaces, is no longer available at a reasonable price. These furnaces are also less costly to build than the complicated shaft furnaces which have been used in Sweden for the last three decades.

Eleven iron reduction furnaces of this new type have recently been built (see Fig. 1), of which nine are of between 6,000 and 9,000 k.v.a. and two are of 12,000 k.v.a., the electrodes being arranged in a line in the former and in a triangle in the latter case. These furnaces produce iron from a 50 per cent. iron ore with a power consumption of 2,400-2,600 kw.-hrs. per ton for ordinary iron, or 3,000 kw.-hrs. for high-silica irons. These furnaces are all equipped with Soderberg continuous electrodes and automatic and gas-tight charging shutes, and about 700 cub. m. of gas containing 75-80 per cent. of CO and of 2,500 cal. per cub. m. are recuperated. This gas is collected and used for general heating purposes in the works. The coke consumption is about 880 lbs. of coke or coke breeze, and the electrode consumption 18 to 22 lbs. per ton of iron.

It is interesting to note that the power consumption does not differ materially from the figures recorded in 1907, when Héroult was smelting iron ores at Sault Ste. Marie in pit-type furnaces.

This industry of iron smelting in pit-type furnaces has been established in Norway, Sweden, Finland and Italy, where conditions favour electric smelting, but there seems to be no probability of applying this process in Great Britain, where ample supplies of excellent fuel and lean iron ores form the basis of most iron-smelting operations.

The largest furnaces are now of 12,000 k.v.a., but there seems to be no reason why furnaces of very much greater power and output should not be constructed.

A large number of arc furnaces for steel-making have been constructed during the last five years in British and other European steelworks, and it is interesting to note that almost all constructors have returned to the simple three-phase furnaces with three electrodes, of which the prototype may be considered to be the 15-ton furnace built at the Illinois Steel Company's works at South Chicago by that great French engineer, Paul Héroult. In Europe the number of electrodes has generally been limited to three, and there is a strong body of opinion that considers a three-electrode furnace with a capacity of about 30 to 40 tons for liquid metal or 20 tons for melting cold scrap, of 8,000 to 10,000 k.v.a., as the largest unit that is convenient to operate.

The electrical equipment is generally of simple and strong construction, the electrodes being either electrically or hydraulically controlled by automatic regulators. A large number of furnaces are now being built with hydraulic control, which has the advantage of a more rapid and flexible movement than that which is obtainable with small motors and reduction gears. Some operators dislike hydraulic equipment near a furnace, but, with careful design and well-made equipment, the hydraulic control is quite as satisfactory as electrical apparatus. The difficulty of "hunting," which has been prevalent with various types of regulator, gave some trouble when hydraulic control was first introduced, but this has been overcome by the proper design of the apparatus and pipe-fitting. The choice at present is largely a matter of personal preference.

The electric regulators are of various types, but do not differ materially from those that are well known in the United States. The main electrical equipment of electric furnaces now usually consists of a transformer and reactance coil, often built in a single tank with taps and star-delta change-voltage apparatus, external coolers with oil-circulating pumps being usually preferred. The rating of transformers has been given careful consideration, so as to obtain a maximum output under furnace working conditions, and provision is usually made for heavy overloads for melting periods.

Table I gives characteristics of three furnaces of modern European design.

TABLE I.—*Characteristics of Modern European Design.*

	A.	B.	C.
Capacity ..	66,000 lbs...	26,000 lbs...	50,000 lbs.
Power ..	6,000 kva.	3,500 kva.	9,000 kva.
Secondary voltages	200–140 .. 120–85 ..	200–140 .. 120–85 ..	280–150 162–86
Max. amperage	19,500 ..	11,200 ..	23,000
Electrodes ..	16-in. graphite	20-in. amorphous	28-in. Soderberg
Roof ..	Fixed ..	Removable	Removable
Regulators ..	Electric ..	Electric ..	Electric
Hearth ..	Fixed ..	Fixed ..	Rotating 60 deg.
Transformer	Natural, external circulation	Natural, external circulation	Oil circulated to external water-cooler
Reactance, excluding furnace	20 per cent.	20 per cent.	15 per cent.

N.B.—In all cases, the main and change switches are operated from the furnace control cabin by electric distant-control mechanism.

Important developments in the construction of furnaces have occurred in the last few years, especially as regards removable roofs for rapid charging, and rotating hearths.

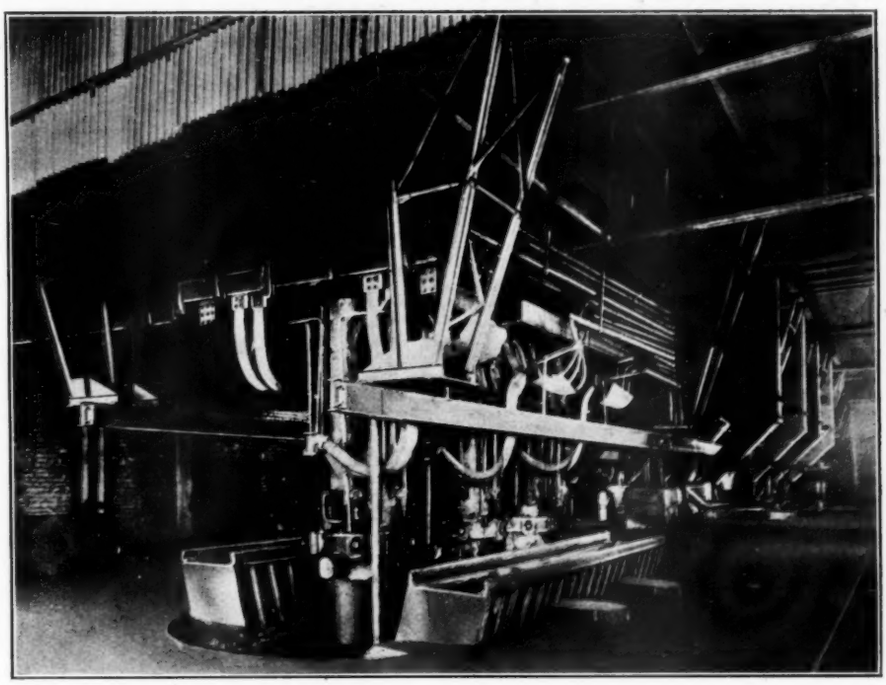

FIG. 1.—IRON-ORE REDUCTION FURNACE WITH GAS COLLECTORS.

Rapid charging is commonly effected by the removal of the roof and electrode mechanism by an overhead bridge crane, by horizontal movement of the furnace body, or by swivelling the roof, as is practised in several furnaces in the United States. By either method much time is saved, and, in the case of furnaces for charging cold scrap, this construction is likely to be generally adopted (*see* Fig. 2).

In the case of swivelling-roof furnaces, the lifting cylinder is often placed on the furnace and the roof raised by a forked structure lifting the roof at two points, which allows the roof to settle down on the body more efficiently than in the case of a rigid structure.

The removable-roof furnace has the great advantage that it can be filled to the roof instead of the door level, as with a charging

* Paper (slightly abridged) presented at the Autumn Meeting of the Iron and Steel Institute in London.

machine, and, as a result, the whole furnace charge can generally be loaded at a single operation, with a minimum of effort on the part of the furnacemen. Consequently the crew on the furnace platform can be substantially reduced in the case of large furnaces. In many works, turnings are crushed to obtain denser packing in the furnace, but the use of bundling presses is not common for the preparation of charges.

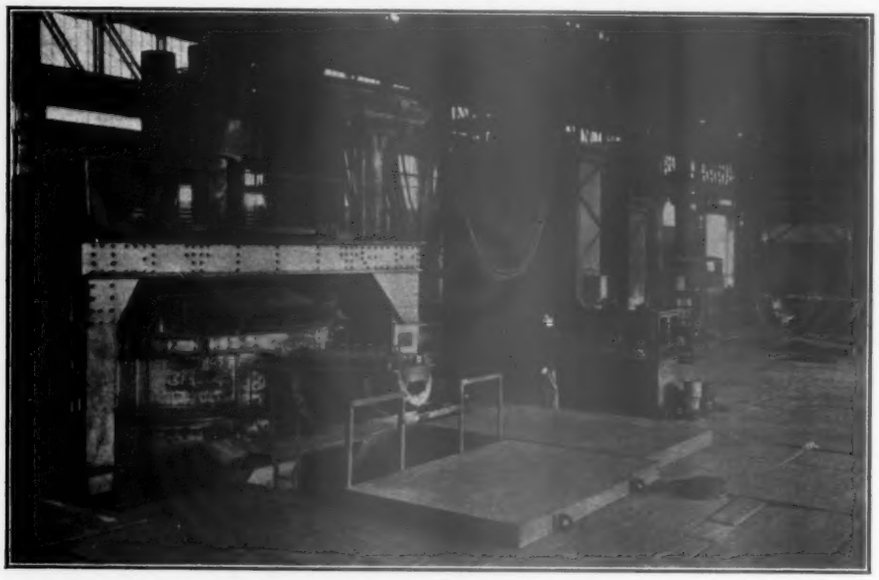

FIG. 2.—ARC FURNACE WITH REMOVABLE ROOF.

Various types of charging baskets have been used successfully. The preparing of charges in steel nets has been used, but as the net was lost in each charge this method has given way to other devices, owing to the high cost.

A basket consisting of radiating flexible steel plates attached at the centre by a rope, which burns on entering the furnace, is used extensively, and also hemispherical self-dumping buckets. A simple cylindrical box, with hinged bottom and self-tripping catch, which operates when the box is lowered on to the furnace bottom, is cheap and efficient.

The saving of time, heat and labour resulting from removable-roof furnaces is one of the major improvements of recent years. The charging of a 3-ton swivelling-roof furnace is now completed in one or two minutes, and five minutes is sufficient to charge a 20-ton unit with a bridge crane.

The latest mechanical device is the rotating-hearth furnace (*see* Fig. 3). In the case of some large furnaces, the hearth is mounted on rollers capable of being rotated about 60 deg. when the roof and electrode mechanism are raised. In furnaces of high power, especially when melting turnings, three holes are rapidly burnt in the charge, and the electrodes and roof are then raised, the hearth is rotated and melting is recommenced. With some classes of scrap there is a saving of about 25 to 30 min. per heat on powerful furnaces of 6,000 k.v.a. and 20 tons capacity.

There is no definite evidence yet available as to whether it is worth moving the bath during the refining period to improve or accelerate the refining and homogeneity of the metal. A considerable number of furnaces are, however, being built with this rotating hearth.

In Europe, the best sizes of electric-steel furnaces for melting cold scrap are considered to be units of 3 to 15 tons, but for duplex working with the basic-Bessemer process, which is extensively used in Europe, the electric furnace is usually of the same capacity as the Bessemer vessel, *e.g.*, 25 to 30 tons.

Many furnaces still operate on the well-known methods of melting and dephosphorising with a lime/iron-ore slag at comparatively low temperatures, slagging and finishing under a white desulphurising and deoxidising slag of lime and fluorspar. Several new processes or changes in metallurgical methods of arc-furnace practice have, however, been introduced in recent years, resulting in great acceleration of the chemical reaction.

A remarkable discovery was made a few years ago—that violently-oxidised metal, after the dephosphorising slag was removed, could be reduced to a properly killed steel of remarkable freedom from inclusions by rapid and violent agitation with a suitable slag free from oxide of iron.

FIG. 3.—ROTATING-HEARTH ARC FURNACE.

Further, it was found that sulphur could be removed by the use of an ordinary lime/iron-ore slag if the temperature were raised and precautions were taken to keep a high percentage of lime and low silicon contents in the slag. These discoveries are leading to a revolution in arc-furnace practice in some European works, and the time spent in finishing a steel after it is melted is being reduced from hours to minutes.

How far these rapid methods of steelmaking may be applied without prejudice to quality is to some extent an open question, but for many qualities of steel excellent results, as regards freedom from inclusions and general chemical and physical qualities, are obtained, and the steel is definitely as clean from non-metallic inclusions as steel made by more orthodox methods. This rapid method of steelmaking has not yet been proved altogether satisfactory for austenitic chromium-nickel steels, and the general method used in Europe for making these steels involves a long quality-refining process when arc furnaces are used.

The above remarks apply to the rapid method of deoxidising steel by mixing the steel violently in a ladle with a slag containing less than 0.5 per cent. of FeO. Within 60 secs. the steel is deoxidised and the oxide of iron in the slag is increased, so that the slag must be returned to the slag furnace for reconditioning, or scrapped and a new slag used. At present the percentage of slag used is so small that recovery of the slag is hardly worth the inconvenience and expense.

In addition to deoxidation, important work is being done with dephosphorising slags, especially for the duplex refining of basic-Bessemer steel, and the possibility of carrying out important refining operations almost instantaneously by violent mixing of slag and metal is being recognised, now that it has been well established that such treatment does not necessarily lead to any increase of the inclusions in the steel.

In addition to rapid refining by agitation with liquid slag, similar work is being done with solid-slag-making materials. In duplex working, dephosphorising is now effected by pouring the liquid metal on to suitable slag-making materials, with the result that the dephosphorising slag can be removed in 10 min. and a complete refining operation completed in less than 1 hr. in an electric furnace, as compared with 1½ to 2 hrs. which was customary for a dephosphorising and desulphurising operation.

The arc furnace is generally recognised as a producer of exceptionally clean steel as regards inclusions, and it is interesting to note that a most careful and exhaustive examination made in several of the leading research laboratories of ingots made by this rapid deoxidising process has proved that the number of the inclusions is no greater and the quality of the steel no worse than when the steel is made slowly in

arc furnaces by the ordinary process with the utmost care and skill.

Refractories

The question of refractories is receiving constant attention, and some improvement in quality of silica bricks has been made. The majority of furnace operators still use silica roofs for basic working, although great efforts have been made to introduce magnesia and magnesia-alumina and magnesia-chrome mixtures. Recently, an important improvement has been made in the manufacture of dolomite bricks, which can now be obtained entirely stable as regards disintegration by humidity. This makes possible the transport and storage of dolomite bricks, and it is a development of importance to those countries aiming at internal self-sufficiency, as dolomite is widely distributed, whereas magnesite deposits of suitable quality for brickmaking are comparatively rare. This development is due to a new method of preparing the dolomite, by which no free lime remains in the brick, and the results are certainly excellent as regards stability in damp weather.

The choice of electrodes is also an open question in Europe, but the amorphous electrode is tending to disappear, and most of the new furnaces are equipped with graphite or Soderberg electrodes. The issue between these two types of electrodes has been somewhat complicated by commercial considerations, but steelmakers who want the cheapest electrode usually adopt the Soderberg system if they have a number of large furnaces, whereas the makers of the highest grade of steel, who usually have smaller furnaces and a small number of units, use graphite.

When Soderberg electrodes are used in steel furnaces, it is usual to have two sets of electrodes for each furnace, one of which is in use and the other, when removed from the furnace, is cooled and extended by 6 ft. or more, and the two sets are thus used alternately. The necessary plant for welding the plates, preparing and ramming the carbon paste, etc., is justified when several large furnaces are in operation, as in the case of many works in Sweden or the Alps, where electric furnaces are more economical than small open-hearth furnaces, but in works where there are only one or two furnaces the cost and maintenance of this equipment militate against the use of Soderberg electrodes.

In one works, where eight arc furnaces are in regular use, electrodes of 20 in. dia. are used, and a new furnace of 10,000 k.v.a. is being constructed with a removable roof and rotating hearth and Soderberg electrodes of 28 in. dia. The current-carrying capacity is greater than that of amorphous electrodes but less than that of graphite. There are many furnace users who prefer the large heating area obtainable with electrodes of great cross-section. With the Soderberg electrode there is a substantial reduction in electrode cost, but many steel melters prefer the convenience of the smaller graphite electrode.

The general indications are that Europe will adopt more removable-roof furnaces, with or without rotating hearths, but that the size of units will continue to be up to 20 tons for cold working, and 30 to 40 tons for refining liquid steel, and there is little inclination to build furnaces of the large sizes that have been constructed in the United States. Revolutionary metallurgical methods seem more likely to increase outputs and reduce costs in the near future.

The high-frequency furnace, a conception which was first developed in the United States, has made exceptionally rapid progress in Europe, and, although this interesting method of steelmaking has been introduced only ten years, there must be more than 300 furnaces in operation for commercial production, in addition to more than 200 small installations used for experimental and development work.

The first steel furnaces were built in wooden boxes, and it is interesting to note that two such furnaces are still in regular productive operation after ten years of regular work. This method of construction was soon replaced by bronze frames with asbestos-cement boxes. As the furnaces grew larger, steel structures have become necessary, and these may be protected from inductive heating either by laminated iron shields or by copper shields. The former method has been used in most European countries, other than Germany, where there has been a considerable development of large furnaces built with copper shields. The former is perhaps the strongest and most elegant solution of the difficulty of inductive heating, but is more liable to damage if metal breaks through. The latter, however, has the disadvantage of being much larger and the whole furnace structure is more bulky.

The capacity of furnaces generally varies from 500 to 18,000 lbs. and the power from 100 to 1,600 kw. It is necessary that these furnaces shall be charged to capacity, and the size of furnace body is therefore important. Consequently, in most works, several bodies of different sizes are installed, so that small orders, experimental heats and light castings, or larger production jobs can be economically done with various sizes of bodies operated from the same electrical machinery, which constitutes the major investment in the plant.

There is also some difference of opinion as to the best size of furnace body to give the greatest output for a given machine. To examine this question, two bodies of 1 ton and 2 tons, respectively, were operated alternate weeks from the same 650-kw. generator, first on an hourly schedule, with a 1-ton furnace, and secondly on an approximately two-hourly schedule with the larger body. The latter method of working gave about 14 per cent. more output, owing to the saving in charging and casting time, and for many classes of steel the extra time in the furnace was considered advantageous.

In exceptional cases, it has been found possible to cast large ingots where one machine and two bodies are available, by melting one charge and then the other, reheating the first and then pouring both lots of metal into a ladle. The loss of heat while waiting was found to be less than was anticipated, and this procedure can be adopted for making large individual ingots or for making composite lumps of two different qualities of steel.

The majority of furnaces are used for simple melting operations, siliceous linings being used for tungsten and most alloy steels. Both acid and basic refractories are used for austenitic chromium-nickel alloys, and basic linings for manganese steels. Siliceous linings last from 60 to 300 heats, and in most countries patching is regularly used after 40 to 50 heats, the new material being fritted with steel-sheet cylinders in the usual way.

Basic linings of magnesia and magnesia-alumina mixtures are in general and successful use for small furnaces of up to 2 tons, but difficulties are encountered in making successful basic linings for furnaces of 5 to 6 tons, though there is no doubt that great progress is being made in Great Britain with this difficult problem. The use of crucibles is completely superseded in favour of fritted linings of carefully-prepared refractory grains.

The removal of sulphur and phosphorus in induction furnaces has not been widely practised, because in most cases these furnaces are used for melting and alloying purposes only, but great progress has been made in what is now called "quality refining," which consists of maintaining the steel for a period under a suitable slag at the correct temperature to improve the physical characteristics of the steel when cast. The high-frequency furnace is excellent for this purpose, as there is no possibility of the local overheating which may occur with the arc.

(To be continued.)

Overseas Foundry Trade

(FROM A SPECIAL CORRESPONDENT.)

France

In spite of a certain irregularity in the flow of business, and a definite weakness in the north and north-eastern regions, the French foundry trade seems to be on the upgrade during the past few weeks. Founders in the frontier regions, especially, who were particularly badly hit by the political crisis of the end of September and early October, have been able to make up for lost time. Heating appliances especially have shown some improvement, there being an urgent need for filling orders on hand. In cast-iron pipe, business is also better. There is a certain difficulty in obtaining orders on account of the unwillingness of municipal authorities to pay the current prices, but these are being overcome. Most founders have stocks on hand which permit deliveries of fair sized orders almost immediately. Castings for agricultural implements are a little more active than during the past few months, though the volume of business is less than last year and customers expect very rapid deliveries. Founders of cast-iron brake shoes for the railways are watching with interest the tests now going on at Vitry. It is likely that future orders for cast brake shoes will include a clause providing for a minimum of quality and wearing ability.

As regards the light alloy trade, a certain difficulty is being experienced almost everywhere in completing orders for civil consumers. Nearly all the plants are occupied with filling orders for the national defence ministries, and military controllers are watching to see that these orders receive priority in execution. A portion of the capacity of the foundries is being reserved for certain civil work, notably for the motor-car industry. Civil orders are being executed with a delay of from two to three months. The difficulty, it is explained, lies in the absence of qualified workmen and in the inability of the foundries to obtain any authorisations for overtime work.

Production of pig-iron is also on the up-grade. Since July there have been no new blast furnaces closed down, while two have been relighted. Stocks of pig are still considerable, however, but foundries expect a slow but steady improvement in the coming weeks. Orders are being taken only for short term deliveries, and to be paid for at the current price at time of delivery. This seems to indicate that price increases are expected.

A system for the surface hardening of castings has been patented in France by Louis Renault (French Patent No. 810,804). The hardening is carried out by heating the surface and then cooling it rapidly. Heating is obtained by placing the casting within the field of flux of a high-frequency current of about 1,000 cycles. The current set up on the surface of the casting causes this surface to heat up. Generally a treatment of from 2 to 3 secs. is sufficient to bring the surface to the correct temperature. Cooling is then effected by means of a stream of chilled gas or air.

Belgium

The opinion, widely held in Belgium, that the present territorial readjustment in central Europe is the precurser of an even more vast readjustment of economic currents, is causing hesitation in many circles. Much fear is expressed that the next six months will see many of Belgium's present markets for pig and castings divided among more powerful groups. This is leading many foundries to wonder whether the continuance of Belgium in the international cartel is a wise move. It might be wiser for Belgian industry to "free lance," without the restraint of international agreements as to price, though the game would be a dangerous one.

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A Liverpool Propaganda Meeting

EXPANDING I.B.F. INFLUENCE

A special meeting of the Lancashire Branch of the Institute of British Foundrymen was held at the Engineers' Club, Liverpool, on October 27, Mr. H. V. Grundy presiding. The purpose of the meeting was to enlist the interest of Liverpool foundrymen in the activities of the Institute, and to explain to them what were its most immediate aims and objects.

The CHAIRMAN, opening the meeting, said his friends from Manchester would feel gratified that there were so many Liverpool engineers in attendance. The idea of holding the meeting was originated by Mr. R. A. Miles, who was present at one of the meetings of the Liverpool Engineering Society, the previous session, when a Paper was read by Dr. Norbury. Being particularly impressed by the subject matter of that address, and by the great interest taken in it, Mr. Miles thought if a meeting of the Lancashire Branch could be held in Liverpool, it might have the result of enlarging the membership of the Institute and increasing the general interest of foundrymen in its affairs.

Foundries in Liverpool

Of a total membership in the Lancashire Branch, numbering between 300 and 400, there were only five members from Liverpool or its environs. When it was considered that in Liverpool itself there were more than 20 foundries, while there were also others in the surrounding districts, together with the fact that in the Liverpool area there were something like 400 skilled operatives, it was a matter for surprise that so little interest was taken in that area in the work of the Institute.

The fact that Liverpool members were present at the meeting was a sufficient indication of a desire in their minds to keep in stride with modern developments. What better means was there of doing this than to become members of the Institute?

The Chairman then stated that, upon the present occasion, the Papers which would be presented would be of a more practical type than perhaps was the one presented by Dr. Norbury when he visited Liverpool. They were based upon thoughts and convictions formed during actual work in the foundry itself. First, Mr. E. Longden (foundry manager of Craven Bros., Stockport), who was the author of numerous Papers on foundry practice, would present a Paper on "Some Notes on Medium and Heavy Grey-Iron Castings." The second speaker, Mr. A. Phillips (Assistant Superintendent of the foundries of Metropolitan-Vickers) was also the author of several Papers, and would deal with "Some Points on Non-Ferrous Foundry Practice."

Following the presentation of these two Papers, each of which was read by the author, the CHAIRMAN suggested that, before the meeting proceeded to the discussion, they would like to hear some remarks from the Secretary of the Institute, Mr. T. Makemson, who was also secretary of the Foundrymen's International Technical Committee.

Objects and Activities

MR. T. MAKEMSON said that possibly some of those present who were not members might have asked themselves "What is the Institute of British Foundrymen; who are its members, and what does it do?" The Institute was a technical association, the sole object of which was to promote the improvement of the craft and science of founding. It had nothing to do with wages and nothing to do with prices. Purely and simply, it desired to make the practice of founding better.

Its members consisted of people of all types in the foundry industry, from the director to the operative. They were all welcomed, and there were grades of membership to meet their varied requirements.

The Institute did many things. Probably the most obvious of its activities was the holding of regular meetings in about 20 cities and towns throughout the country; and regularly also in one town in South Africa, and occasionally it held meetings in other overseas countries. The nearest meeting place to Liverpool was Manchester, and whether meetings would be held regularly any nearer to Liverpool in the future would depend naturally upon how many people from Liverpool were prepared to support such meetings.

Frequent visits were arranged to foundries in order that members might have a chance of comparing their own practice with that of other people. This was perhaps one of the most valuable features of the Institute's activities. That night they had heard selections from two Papers, both of them of a most valuable character. Such Papers were read all the year round, and were afterwards published in a volume of Proceedings of about 800 pages. Copies of those Proceedings were sent to most grades of members as a part of their membership privileges.

Standardisation

Another feature of the Institute's work was an employment bureau. The Institute also did a great deal of work of a general character for the industry. For example, in recent years it had taken a very active part in the preparation of British Standard Specifications. Whether they liked it or not, foundrymen were having to work more and more to specifications, and the Institute, through its representatives on the committees of the British Standards Institution, endeavoured to see, and usually did see most successfully, that specifications were drawn up in such a way as to make it possible for foundries to work to them with a reasonable degree of success. In other words, if they had to have specifications, then the foundrymen generally should have a finger in the pie in drafting them.

These activities involved a considerable amount of work on the part of some members of the Institute. The whole of the work, with the exception of the usual amount of administrative work done in the Secretary's office, was carried out gratuitously by members themselves.

Perhaps the most important benefit that membership of the Institute conferred was the opportunities it provided to the members of becoming acquainted with one another, and of meeting others doing similar work, or perhaps even doing different work but with similar problems to solve. The mutual benefits which resulted could certainly not be computed in figures, but he was quite certain that many people who had been members of the Institute for some years would endorse his statement that such contacts were an extremely valuable part of the privileges of membership.

The Institute had done a great deal to promote progress in foundry practice. All of them who were 40 years of age, or even 30, knew that foundry practice to-day was very different in many respects from what it was a few years ago. It was altering very rapidly. The new developments which were taking place were necessary not merely to enable the foundrymen of this country to make a better product, but also to cope with the competition with which their products were faced from other alternative forms of construction.

Although these alternative forms of construction might be hurting foundries in certain directions, nevertheless the industry as a whole was still growing, and it would only continue to do so by virtue of the fact that it was enhancing the quality of its products. The industry was manufacturing new products with new properties, it was adapting itself to new methods, and it was using new plant. As the Chairman had stated, probably the only way in which a foundryman could keep abreast of modern developments was by becoming a member of an Institute which was most naturally concerned with such developments.

It might be difficult for some people to attend the meetings of the Institute situated as it was at present, but there were members of the Institute in Liverpool who did attend the Manchester meetings fairly regularly. There were even members attending who lived at much more distant places than Liverpool, and who felt that it was worth their while to be present at the meetings. The time was coming, in fact, when foundrymen would have to ask themselves—not "Can I afford to be a member of the Institute?" but "Can I, if I am progressive and want to make a name for myself in the industry, afford not to be a member of it?"

An Appeal to Proprietors

After the Papers had been discussed, MR. R. A. MILES said that, being partly responsible for the meeting being held in Liverpool, he was a little disappointed at the number of local people who had attended. He thought there would have been more, because it was mainly in their interest that the meeting had been arranged. The men in charge of the works operations were, of course, always interested in the Institute's activities, but the apathy of foundry proprietors, generally speaking, was quite noticeable. Although they did not attend the meetings of the Institute, they were well aware of its value. He thought there must be a feeling at the back of their minds that the members of the Institute wanted to get something from them. As a matter of fact, they did. They wanted to gain their friendship. They wanted to prove to them that those foundrymen who had been members of the Institute for a long time had gained worth-while experience by being members. Perhaps the notice for the holding of the meeting had been insufficient, or perhaps the evening was not the most suitable one in the week. Nevertheless, he suggested that the impetus given should not be allowed to lapse, and that the Institute should endeavour to hold another meeting in Liverpool next spring. Perhaps then there would be a better attendance, and a more certain prospect of an increase in the Institute membership.

Local Opinion

MR. W. BROWN (Chairman of the Liverpool Ironfounders' Association) said that there had certainly been a lack of opportunity for some Liverpool foundrymen to attend the meeting. Another point to be considered was that this meeting was the first which had been held in Liverpool in his experience. The fact that the Liverpool people might have to travel to Preston or Manchester would not be conducive to them becoming members of the Institute. Most of them could not afford to spend the time away from their places of business. The Liverpool firms were practically all of a small nature, and trade depended to a very great extent upon personal touch with local customers.

There were about 21 ironfoundries in the city, only two of which were fairly large organisations with large staffs. If meetings were held regularly in Liverpool itself he thought he could almost promise definitely that the Institute would enjoy a larger membership. Liverpool was not afraid that anybody would come and exploit any information concerning the work which was being done. Liverpool had no trade secrets; its founding industry might be likened to an open book, and he thought everybody in the trade was willing for anybody else to go through their works.

MR. W. BROWN proposed, and MR. R. A. MILES seconded, a vote of thanks to the lecturers.

Principles of Gating and Feeding*

THEIR APPLICATION IN PRACTICE

By A. M. CAMPBELL (G. & J. Weir, Limited)

This is a subject of great controversy, as opinions have been formed and re-formed, and one foundryman's experience has clashed with another's, until one begins to realise that there can be no question of orthodoxy, but rather a question of the sensible application and recording of past experience with different types of castings, due consideration being given to the physical properties of the metal cast.

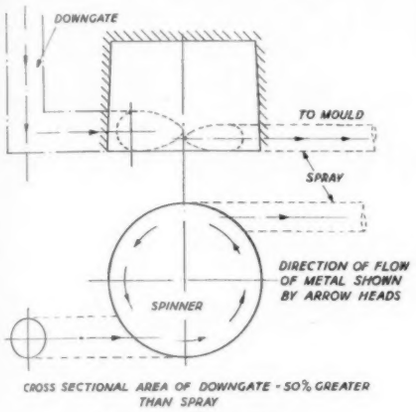
DOWNGATE
TO MOULD
SPRAY
DIRECTION OF FLOW OF METAL SHOWN BY ARROW HEADS
SPINNER
CROSS SECTIONAL AREA OF DOWNGATE - 50% GREATER THAN SPRAY

FIG. 1.—SPIN GATE.

The practices which are to be described may cause further controversy, but they are examples in cast-iron and non-ferrous alloys which have been found entirely successful in personal experience.

Fundamentals

First of all, certain fundamentals in gating and rising must be adhered to. These are:—

(1) To decide the type of gate which is best suited and most convenient to use on the type of casting, or kind of metal being considered, *i.e.*, whether drop gate, bottom-poured gate, or a combination of both.

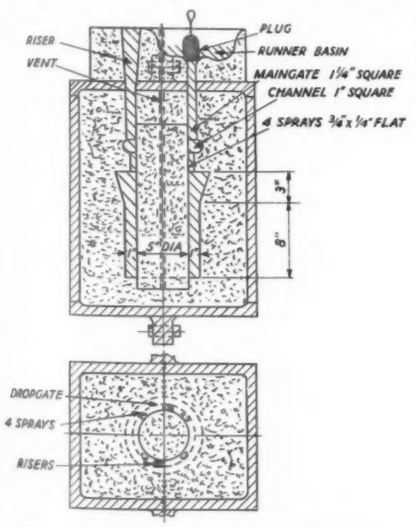

FIG. 4.—TYPICAL DROP GATE FOR SMALL WORK.

(2) The correct size and shape is of next importance, as they govern the speed of filling; consideration should be given to the relation between the cross-sectional area of the main gate and the sprays taken from it. Personal experience suggests that the main gate cross-sectional area should be 50 per cent. greater than the total cross-sectional area of the sprays taken from it, this extra allowance being made to take care of any flash which may form.

(3) In order to ensure clean metal entering the mould, the use of dirt or slag traps may be necessary. There are several different forms of these traps.

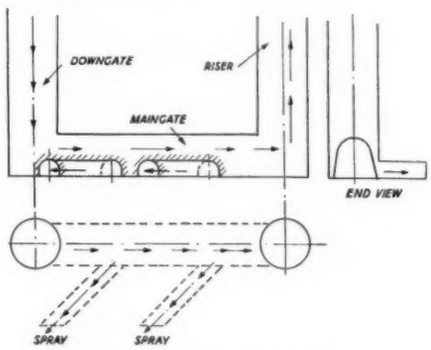

FIG. 2.—BYPASS GATE.

Cross-sectional area of Downgate is 50 per cent. greater than Maingate, and total cross-sectional area of sprays is 50 per cent. less than Maingate.

Types of Gates

Fig. 1 shows the spin gate, so constructed that the metal from the downgate swirls in the spinner and the motion given to the metal causes the dirt to rise to its centre, allowing a clean stream of metal to pass to the spray. Fig. 2 shows the bypass gate, in which type of gate a riser is connected to the downgate by a channel from which the sprays are cut at a tangent. The flow of metal from the sprays is against the flow of metal in the downgate, which is an important factor. In the direct trap gate shown in Fig. 3, a dummy riser is placed between downgate and spray for the retention of any dirt in the metal. The dirt can only be retained if the relation between the downgate and spray is correctly proportioned.

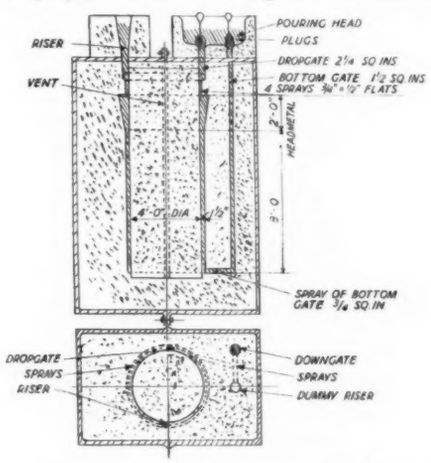

FIG. 5.—TYPICAL USE OF COMBINED DROP AND BOTTOM POUR GATES.

(4) In feeding, the first consideration is the kind of metal to be cast, on account of the variation in liquid shrinkage of different metals. For example, in cast iron the shrinkage is considerably less than in steel, high tensile bronze or Monel. One should bear in mind that all castings must be considered from the angle of the heavy section which will be formed, and adequate risers located at places found by experience as suitable for avoiding shrinkage cavities. Of course, these parts may sometimes be too inaccessible for risers to be taken from them, and in such cases chills or denseners must be used. Finally, the casting temperature plays an important part from a feeding point of view, but this depends to a greater or lesser extent on the kind of metal cast.

Application to Cast Iron

Fig. 4 gives an example of the successful method employed for the running and feeding of a 5-in. diameter cored liner. This is an example of the drop gate which is properly balanced. On this length of liner a 3-in. head is employed to overcome shrinkage, and also to receive any dirt which may have found its way into the mould. Note, however, the safety precaution of plugging the main gate in the pouring head, which is first filled with metal before the plug is removed. If this pouring head is maintained full, all dirt should be trapped on the surface of the metal. The drop gate is so arranged that metal on entering the main gate is diverted by means of a channel cut in the circumference of the top print, thence through the communicating sprays to drop perpendicularly into the mould.

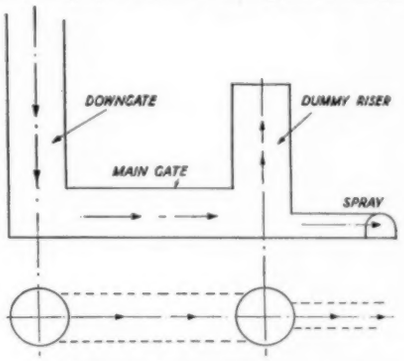

FIG. 3.—DIRECT TRAP GATE.

Cross-sectional area of Downgate is 50 per cent. greater than Maingate, and total cross-sectional area of sprays is 50 per cent. less than Maingate.

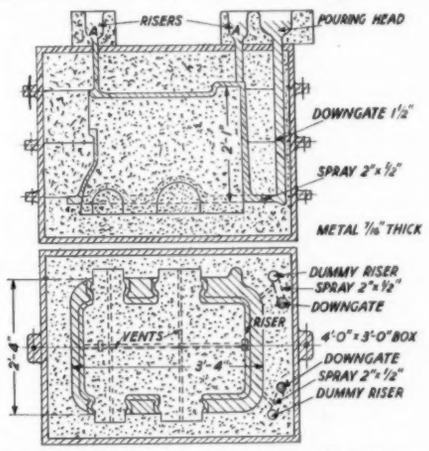

FIG. 6.—BALANCE OF GATES. THERE ARE 2 SPRAYS OF 2 SQ. IN. TOTAL AREA AND 2 DOWNGATES OF 3 SQ. IN. TOTAL AREA.

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* Paper presented to the Scottish Branch of the Institute of British Foundrymen, Mr. Evan J. Ross presiding.

Fig. 5 illustrates the gating of a large liner using a combination of the drop and bottom gates. The drop gate, being the same as in the example of the small liner, needs no further explanation. The additional gate, however, is bottom run and formed on the by-pass principle. It is a medium whereby a small amount of metal is admitted to the mould by plugging the drop gates as shown, forming a cushion on which to receive the bulk of metal admitted

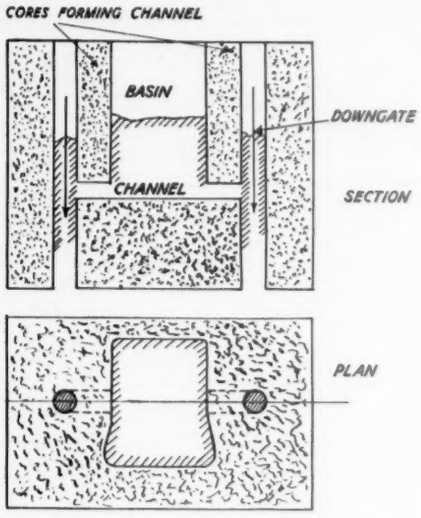

FIG. 7.—SECTION AND PLAN SHOWING FORMATION OF SKIMMED RUNNER BOX.

by the series of sprays. This cushion effect protects the bottom of the mould from the shock it would receive if the bottom gate were omitted. In moulds of abnormal depth, the use of the combined drop and bottom gate is good practice.

Fig. 6 shows the use of the bottom gate with dirt trap and skimmed pouring head as applied to a gearcase. Two downgates both run from the one pouring head, a single spray being taken from each and run to the bottom flange, thus ensuring quick covering of lowest part of mould and reducing the likelihood of scabbing to a minimum. Risers as shown in Fig. 6 are suitably placed for feeding purposes.

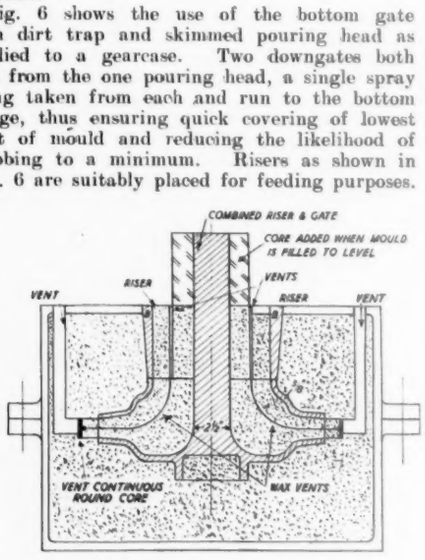

FIG. 9.—MOULD FOR 14-IN. DIA. EXTRACTION PUMP IMPELLER.

The skimmed pouring head, as shown in Fig. 7, is constructed by using cores grooved to form a communicating channel between the downgate and the basin. These cores are rammed in position. The head box is then stoved and dried with the mould and placed in position prior to casting. The head is kept well filled and only clean metal can enter the downgate. The trap provided at bottom runner takes care of any dirt which may possibly enter the downgate at the commencement of pouring.

Application to Monel Metal

Monel Metal is an alloy of 65 per cent. nickel, 32 per cent. copper, 0.5 to 1.0 per cent. manganese, and 0.5 to 3.0 per cent. silicon. Care must be taken in casting this material on account of its high liquid shrinkage and high pouring temperature (1,560 deg. C.). In practice the production of castings is more or less similar to steel. The sand for cores and moulds must be highly refractory and ample feeding heads allowed to overcome shrinkage troubles. Gates and risers require careful consideration, as every

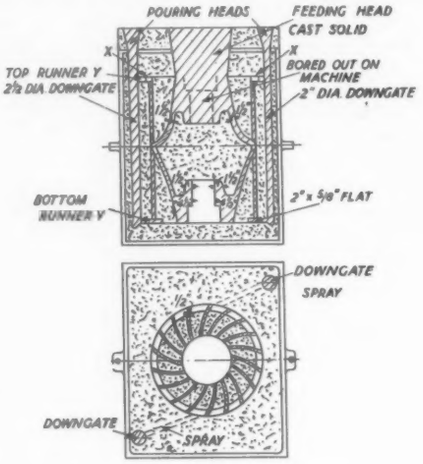

FIG. 8.—LARGE PUMP ROTOR.

casting is a problem in itself. There is no general rule to be followed for gates and risers, but the high contraction (¼ in. per ft.) must be taken into account. Sprays are made proportionately greater than those used for similar castings in cast iron, this proportion being in the region of 50 per cent.

The method of feeding and gating a large pump rotor in Monel Metal, shown in Fig. 8, was adopted after some unsuccessful attempts had been made using a drop gate on the boss in centre of mould. The centre boss is about 1½ in. thick, and the hubs at top and bottom about 4½ in. thick. To these 18 blades of ½-in. section are attached and shaped as shown in plan. There are two stay ribs about 1½ in. by ½ in.

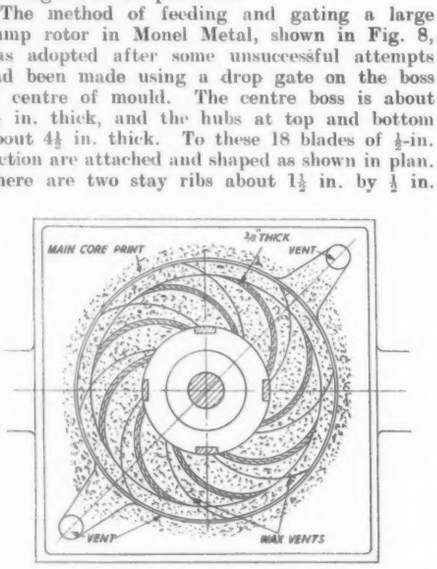

FIG. 10.—PLAN OF PUMP-IMPELLER MOULD SHOWN IN FIG. 9.

at the top and bottom of the blades as shown at XX.

The varying thickness of metal caused unequal balance of cooling, which was further aggravated by the position of gate; for example, when cast in the hub, the casting cracked due to uneven cooling on contraction. To overcome this defect, top and bottom running at the stay ribs, *i.e.*, at YY was used; this more even heat distribution overcame the unequal heat balance. The riser provided for feeding is of the same diameter as the boss on the casting. The riser is cut off before machining.

On every Monel casting a patent refractory (black in colour) is used to cover all feeding heads after casting. This refractory helps to keep the feeding head liquid, thus preventing the formation of shrinkage cavities.

Figs. 9 and 10 show the section and plan of a turbine extraction pump impeller mould. This impeller is fairly uniform in section, the eight blades being ⅜ in. thick. The top and bottom shrouds are also ⅜ in. thick. The heaviest section is the centre boss, which is 2½ in. thick. As this casting is machined all over, great care has to be taken in arranging gates and risers, and providing ample vents to ensure soundness. However, this example is straightforward and is typical of normal production with Monel Metal. A combined gate and riser is used down the centre of the boss. This arrangement is used for two reasons: (1) because it is the point which gives quickest access to all parts of the mould, including the blades, and thus is ideally located for gating, and (2) it is the heaviest section of the casting, and thus the part most requiring adequate feeding. Risers are also taken from top of packing ring diameter for feeding purposes as shown at BB.

(To be continued.)

Notes from the Branches

Newcastle.—The opening meeting of the Newcastle-upon-Tyne Branch of the Institute of British Foundrymen was held on October 29. There was a good attendance, but members learned with regret from Mr. G. Elston (Branch-President), who presided, that the Paper originally intended for presentation could not be read. This was to have been "Ironfounding in Hong Kong," by Mr. Sidney Simpson.

MR. ELSTON stated that Mr. Simpson's holiday in this country had terminated earlier than expected, and he had actually that day embarked for Hong Kong. He expressed the hope that at a future date Mr. Simpson would be able to let the Institute have an article on the subject indicated by the title. Mr. Simpson had already had several conversations with members present, who had had the opportunity of examining an excellent collection of photographs showing methods adopted by Chinese labour in Hong Kong.

Mr. Elston, continuing, said that, in these circumstances, he proposed to call upon members who had presented Papers in the Short Paper Competition last March. This competition, he reminded members, was made possible by the kindness of Mr. Sidney Simpson, who had provided a sum of money to be spent on appropriate awards. The first prize had been awarded to Mr. J. L. Smith, a young Associate of the Branch, and before asking Mr. Smith to read his Paper, Mr. Elston thought that it would be very appropriate if Mr. James Smith, Past-President of the Branch, would kindly undertake the duty of presenting the prize awarded to Mr. J. L. Smith, junr., his grandson.

MR. JAMES SMITH expressed his great pleasure in accepting the invitation. It was particularly gratifying to him, he said, to present the prize to a young member of the Institute. In this case he was handing the award, which took the form of two excellent books on foundry practice, to his grandson, who was born eleven years after he himself had become a member of what was then known as the British Foundrymen's Association. He remarked that he himself was perhaps well versed in the practical side of foundry work, but he realised that science had now taken a firm grip upon the industry to its betterment, and he looked forward to the time when the recipient of this award would know as much about the scientific side as he felt he knew about the practical side.

Mr. J. L. Smith then read his Paper on "Some Defects in Iron Castings."

Chilled Iron and Other Rolls*

By A. ALLISON

So far as can be ascertained, the manufacture of chilled iron rolls is the only example of a process originating in one country and spreading thence to other areas. The claim is made for a foundry in Bristol that chilled rolls were first made there, although hard rolls were made at Hayle, in Cornwall, about 1780, which Prof. Louis thinks were a type of hard grain roll. The view must be taken that craftsmen in different localities acquired a skill and reputation for producing certain products, and by lapse of time the production more or less died out, sometimes with the knowledge being passed on, or the idea being preserved by specimens. This probably applies to the early origins of all processes and materials. If a roller found he could get good rolls from a certain foundry, he would not tell his competitors.

The first definite records are those of the German Chamber of Mines, who sent over two representatives in 1814 to the Eagle Foundry, Birmingham, and Claridge & North, of Bilston. The Eagle Foundry is now the stove-grate foundry, and Claridge & North died out in 1876. The German workers persevered through a heartbreaking series of experiments until the foreman, Erhardt, re-invented the spinning runner. Out of their first rolls only one up to the thirtieth, and the last three of 35, were sound, five others being partly usable. The great firm of Krupp say that to compete with the chilled iron rolls from England at the end of the 18th century, Frederick Krupp started to make steel rolls in 1818, and Alfred Krupp from 1830 onwards improved the manufacture, and the development of the firm up to 1850 was due to this success.

Rolls were occasionally discussed at technical societies, and Prof. Turner gave an analysis in 1887. An example of individual effort in distant localities is described by De Loisy in *Revue de Metallurgie* in 1905. Evidently he had made rolls in distant parts of Russia and in France, from synthetic mixtures, with success. Obviously he would not record his work if the rolls were unsatisfactory. This, then, is the beginning of the process of lifting the veil of secrecy, or, in other words, placing the *rationale* of the process on scientific record, and the literature is now quite extensive.

There is one feature about chilled rolls different, it is thought, from most other processes; that is, the human factor cannot be dispensed with. In steel manufacture it is possible to take samples and analyses, and although that can be done in roll manufacture, the chill test, which is the deciding factor, calls for personal qualities of judgment and rapid decision, taking into account all the circumstances, the size of roll, quality, etc. The operator who desires to make chilled iron rolls must stand over the furnace, see the chill test made, observe the temperature and generally watch the whole process himself. Also, if a roll breaks, he must photograph the fracture at once if possible.

Chill Formation

Rolls have to fulfil many requirements. When no great mechanical demands are made, a hard roll cast from the cupola and with no particularly exact depth of chill is adequate, but for difficult and severe demands a lower carbon and exact chill is necessary. The formation of the chill and the hardness thereof are governed by the time factor to a large extent. It seems fairly clear that extrusions or excrescences are formed very rapidly while the dendritic crystals are in process of formation, because there is no sign of any passage through which they could emerge. Also, contact with the chill mould in one place causes the eutectic metal to freeze and prevent its extrusion. This indicates the rapidity with which the chill is formed, the eutectic expelled and the dendritic crystals completed.

It is well known that to produce thin castings with a chilled surface, low-phosphorus iron is necessary and a higher silicon, so that the speed of the chilling action produces a chilled surface, and the higher silicon a grey back. Phosphorus does interfere in this case, but not in fairly massive objects like rolls.

The Lead Contact Process

As regards hardness, it has been found possible to increase this in plain chill by maintaining metallic contact between the roll and the mould. This is the subject of a patent by the Metropolitan-Vickers Company, Limited, and the process consists of injecting molten lead into the space produced very soon after casting by natural contraction.

The process is not unduly difficult to apply. At a given time after casting, depending on the size of the roll, molten lead is poured through a passage moulded in the top part leading to the edge of the chill. At the bottom it is necessary to cast a ring of mild steel plate projecting beyond the chill mould. The iron in casting freezes on to this ring, making a seal, which is necessary because molten lead has extraordinary penetrating powers, and passes easily through the sand of the mould. When the lead has been introduced, it is allowed to remain for one hour and then released by lifting the chill mould slightly. The cooling curves indicate the effectiveness of the more rapid cooling, and the rolls are 8 or 9 degrees higher by scleroscope hardness. In personal experience the life of the roll is also improved.

Alloy Rolls

Alloy rolls call for a different technique, involving that old and difficult problem of the collaboration of the laboratory and practical personnel; in other words, the question of personality and temperament. Nickel is a very obliging metal, as it "stays put"; there is no oxidation. Chromium loses heavily in the air furnace by oxidation, but not so much in the cupola, so that considerable judgment is necessary in melting metals to give the necessary finished composition. The carbon is usually lower and a much higher casting temperature is necessary. It is desirable also to allow these rolls to cool much longer in the pit to ensure that the structural changes are as complete as conditions allow.

Low-Carbon Rolls

American founders are advertising rolls with carbon less than 1.5 per cent., and even less than 1 per cent., and it is obvious that any rolls with carbon less than even 2.5 per cent. require a high temperature for casting and great care in cooling. It is only to be expected also that the percentage of defectives from pulls and splits will be higher. The modern tendency is to look upon carbon as well as silicon and manganese as an alloying element, and modify them to suit the heat-treatment for producing rolls for a definite purpose in the hot mill.

The high alloy rolls render satisfactory service in the cold mills in the cast condition, although it may be necessary to temper them somewhat to make it possible to machine them. One point worthy of mention is that the practice of casting hollow rolls for water-cooling purposes is only advisable if the rolls are used with moderate draughts. If the rolls are to be severely draughted, then they should be solid. This is confirmed by German and other experience.

From some examples (exhibited), both of alloy iron rolls and hardened steel rolls, it is quite definite that the failure commences at the bore and spreads outward, indicating, it is thought, overdraughting. The addition of the larger amounts of chromium and nickel has introduced a new feature into roll manufacture, *viz.*, somewhat different manipulation and heat-treatment.

It is well recognised that there is little point in adding alloys to steel unless the valuable properties are brought out by heat-treatment, and the same thing applies to alloy iron rolls. Of recent years, views have changed in the direction of favouring higher carbon, *i.e.*, there is not so much fear of higher carbon.

Methods of Melting

Methods of melting have changed somewhat, and it is realised that, with iron melted in a hearth furnace of some kind, revolving or stationary, there is a difference in the apparent perfect solution or otherwise. The question is still obscure, but it will be agreed that with metal kept molten for some time on a hearth, there is more likely to be more perfect mixture and solution of the elements than with iron, say, melted in the cupola. Undoubtedly it is very difficult to control carbon in hearth furnaces, except the plain melting type, such as the air furnace, and generally this leads to a demand for a high-carbon pig-iron for charging purposes instead of the low-carbon pig formerly preferred. Manipulation is required to obtain the composition desired, as cast iron does not take up carbon in the spout as steel does, for example, because obviously its solubility is already to a large extent satisfied.

However that may be, control of carbon is desirable so that rolls may be suitable for the purpose intended. Hitherto it seems doubtful if the newer melting machines, rotary and so on, are not too oxidising in this connection, since it is difficult to put carbon back once it has been lost, and, after all, carbon is the supreme element for imparting hardness to iron. As regards silicon, it is well known that silicon and carbon are the inverse of each other, and chill depth is largely contributed by the silicon.

Manganese and sulphur also work together, and there is no evidence that the sulphide inclusions are detrimental. In Germany, high-manganese rolls are made, probably because the native irons are high in manganese. A practical rollmaker has said that foundry rolls with 1.5 to 1.7 per cent. manganese were made, but that manganese should never exceed 1.25 per cent.

It is possible that the most severe demands on a chilled roll are for hot-rolling tinplate, and rolling strip the next. Much investigation has been made into the causes of success and failure of rolls for these purposes, with greatly improved results. Some articles can be tested and their suitability for service determined in advance, but no sample for test can be taken from a chilled roll. What tests can be applied therefore? Chemical analysis is useful and helpful. The scleroscope test is also of some value, and by considering the chill depth in relation to diameter, together with composition and hardness, a good idea can be formed of the serviceability of the roll.

Carbon is *per se* and *par excellence* the graphitising element for obvious reasons, graphitisation being the inverse of chill. Since the chill consists of pearlite and cementite, higher total carbon means a higher cementite pearlite ratio and greater hardness thereby, because cementite cannot be softened by annealing. It was realised some years ago that, for severe usages, the mild roll was more durable, because coarse graphite in the core was avoided, but also the surface is less liable to fire-cracking. This naturally leads to the question of chilled rolls breaking under the influence of heat, and a really satisfactory explanation has not yet been found. The thermal conductivity and thermal expansion of chill are little different from those of grey iron, and

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it is suggested that another factor comes in, *viz.*, rigidity or low plasticity.

The Rôle of Phosphorus

As regards phosphorus, analyses of many rolls which have given good service show a range from 0.25 to 0.7 per cent., so that phosphorus is not detrimental but actually useful. Analyses of samples turned from the barrel are almost invariably of higher phosphorus than the body, and there is evidence that, in the formation of the chill, liquid eutectic is squeezed through the dendritic crystals whilst they are in process of formation. This is also illustrated by the cavities filled with pellets which are produced when a roll is cast cooler than it should be. Phosphorus may therefore be a useful element by welding up any slight imperfections in the chill.

As regards other elements, chromium has long been used in small amounts and seems to toughen the roll somewhat. Allowance for its chilling effect has to be made, also the lag between the chill test and the roll, because most elements seem to produce an extension of the indeterminate zone. The position is difficult because it is necessary to wait until the roll is worn out, say six months. Theoretically, the quicker the cooling the more austenite should be retained, and therefore the roll be softer. Actually it occurs regularly that a roll 14 in. in diameter gives a scleroscope hardness of 80 and a roll of 8 in. diameter cast from the same ladle 95. Tempering the small roll reduces the hardness to 80 or less, depending on the temperature. No perceptible changes can be seen under the microscope, and it would require very extensive research to ascertain exactly what happens, because it would be difficult to reproduce shop conditions on a laboratory scale. Therefore, as pointed out previously, judgment and practice are necessary to produce the result aimed at.

Alloyed *versus* Hardened Steel Rolls

A few words may be said about the relation of alloy rolls to hardened steel rolls. Whilst alloy rolls have been very useful for hot-rolling and cold-rolling in some mills, it is obviously useless trying to force any material into positions for which it is unsuitable. In some mills, rolls are definitely worked up to the limit of their physical properties, and this applies particularly to hollow rolls which may be water cooled. The physical differences between the hardened steel and the alloy iron rolls are not great. Hardened steel rolls have been known to fly in pieces in the shop before use from the tremendous contraction stresses set up by hardening.

Alloy iron rolls will break or split if heated too rapidly for heat-treatment, but, as a rule, if an alloy roll survives three or four shifts, it has a good life in hot-rolling. The regular hardness of steel rolls is over 90 scleroscope, but alloy iron rolls for hot-rolling do not exceed 80, and 85 is definitely unmachinable. For cold-rolling, if a high finish be called for, hard steel takes and keeps a bright surface best, but alloy iron may give adequately smooth finish for the particular purpose. The user must decide from the cost-service ratio which type suits his requirements the better. Additions of quantities of nickel and chromium produce much greater hardness, so much so that such rolls may be unmachinable even with tungsten-carbide tools. Moreover, alloy rolls seem to be more sensitive to temperature gradients than plain chill, that is, they have lower plasticity.

A roll breaks from the combined effect of residual casting stresses, heat stresses and mechanical stresses. Casting stresses and to some extent heat stresses can be relieved by heat-treatment, but mechanical stresses are obviously a matter for the rolling-mill executives. There has been a fair amount of information published on alloy rolls, but obviously the heat-treatment is up to the present regarded as being the concern of the firms involved.

With nickel over 3 per cent. and chromium over 1 per cent., the chill has a structure in which the pearlite is replaced by martensite, giving the increased hardness. This is not invariably the case, depending somewhat on the size of the roll and conditions of cooling. Whatever heat-treatment is given must be done very cautiously, commencing with an almost cold furnace and raising the temperature very slowly. It is believed that casting stresses are relieved at a temperature of 500 deg. C., and some softening occurs which may be advantageous, since, as is usually the case with cast iron, it is necessary to compromise between contradictory factors.

Exactly what the conditions are in alloy chill and what happens upon subsequent annealing are not clear. For example, a small roll may retain some austenite in its structure, subsequent tempering permit the formation of martensite with the effect of increasing the hardness, and subsequent slow cooling permit the tempering of the martensite. From the position of the rollmaker the solution seems to be to treat each size of roll and its service conditions on empirical lines.

Future Tendencies

It is felt that for many mills the heat-treated alloy roll will gradually replace the plain chill or semi-chill for flats and sections. It will require considerable courage to apply alloys to the really large rolls, 10 ft. by 3 ft., for plate mills, but a personal opinion is that the large-scale experiment should be worth while, that is, by co-operation between the rollmaker and user to try out the newest metals. Grain rolls do not seem to give much trouble, as they have a long life and are already very economical, so the scope is somewhat limited there.

It is no use trying to force a material into a position for which it is not the best for the job, considering all aspects, cost, serviceability and life. It is only by accumulating the necessary evidence and information that the difficult question of roll failure can be harmoniously settled.

DISCUSSION

MR. L. W. BOLTON (Branch-President), opening the discussion, complimented Mr. Allison upon his wonderful collection of slides. He was particularly interested in Mr. Allison's remarks regarding the tendency to-day to use a higher percentage of carbon in rolls. He wondered whether Mr. Allison thought it would be possible to produce metal for rolls by cupola melting and duplex melting. Vast strides had been made in cupola practice, and he should have thought it possible that such metal could be used for rolls to-day. It would have a decided advantage because one could get any carbon which was wanted. One of the difficulties of the rotary furnace was the loss of carbon by melting, and it was difficult to replace it. Another point which interested him in the manufacture of chilled rolls was the method by which the test-piece was taken. Mr. Allison had said that the pouring temperature was an important factor. There were manufacturers who said that if the temperature was too high the depth of the chill would not be sufficient, and he wondered if a metal of excessively high temperature would give less depth of chill than if the metal was poured in cold.

Cupola Melting Ruled Out

MR. ALLISON replied that he did not think it possible to produce good rolls from the cupola. There seemed to be some mysterious difference between the hearth furnace and the cupola. In regard to recarburising he had tried experiments with only moderate success. In regard to the casting temperature and the chill, there was a range of temperature within which the test-piece must be kept. The rollmaker had to wait until the test metal had actually cooled down to a certain temperature or he would get a false chill. Mr. Allison observed that he had sometimes found the test-piece shallow and the roll satisfactory. When a test-piece did not attain the standard he always found out what the roll was like.

Surface Cracks

MR. HARRISON asked if surface cracks which Mr. Allison had said were due to bad cooling and could be machined out ever occurred while the roll was being machined. Some of the slides showed free graphite, and he wondered if that existed near the surface. Low carbon content had been mentioned for chilled rolls, and he wondered if that was intended to toughen the chill. Did the rate of pouring have any effect on the depth of the chill?

MR. ALLISON replied that definitely-formed surface cracks were sometimes found in machining, while free graphite occasionally existed near the surface. A low-carbon roll did not crack so easily, and he did not think the rate of pouring affected the depth of chill, but he sometimes wondered if it had any effect.

Scleroscope Readings

MR. F. J. COOK (Past-President of the Institute) asked if Mr. Allison had any formula or any way of obtaining the right balance of silicon and carbon. If an analysis were presented to him, how would he judge whether it was a chilling iron or not? There must be some means of telling when the silicon and carbon were in something like reasonable proportions that one would expect to get a chill. He understood that the German scleroscope readings were ten points or more higher than the English readings. While the personal element in roll-making was one of the chief factors, was there not a governing factor in reading a chill? Whilst the rate of casting might not make a difference, would not excessive swirl make a difference to the depth of the chill?

MR. ALLISON said he did not know of any silicon-carbon ratio. He had sometimes made an analysis and found nothing abnormal. It was possible to get tables showing the ratio of carbon and silicon in the same chill. In regard to the scleroscope, the testing of rolls was difficult. All his figures were recorded by a scleroscope, but the personal factor entered into such readings. If, however, the same man always used the same instrument he should get consistent results. The German scleroscope readings were coming more into line with ours. He did not see how the personal element in roll manufacture could be dispensed with. He admired the rollmakers of a hundred years ago who turned out good rolls. It was true that while they produced six good ones out of ten, to-day they were expected to get eight out of ten. The foundry foreman had a fairly good idea of temperatures, and there was a remarkable agreement between the pyrometer and the foundryman's judgment. The reading of the chill was purely a personal question. They could not get that personal factor without long experience. So far as the temperature of casting went, providing the temperature and the rate of casting were within reason, the chill was generally satisfactory. He had never noticed any effect as the result of an excessive swirl on the metal.

Chill as Related to Raw Material

MR. H. G. HALL asked how long after casting was a chill first quenched, and if there was a greater tendency for low-carbon rolls to develop a heat tear as against high-carbon rolls. Personally, he thought that rolls cast from pig-iron of the same analysis actually gave a greater chill than ordinary grey cast iron, and he wondered whether the old-fashioned rollmaker was not possibly helped by the cold-blast system of iron manufacture.

MR. ALLISON pointed out that the test-piece must be timed. It was usual to strip the piece when it reached about 900 deg. C. At that temperature it should be sprinkled and not quenched. There was undoubtedly a greater shrinkage in low-carbon cast-iron rolls. Cold-blast iron was a chilling iron and essentially satisfactory.

(*Concluded on page* 372.)

Facings in the Modern Foundry*

By H. WINTERTON (Past-President, Institute of British Foundrymen)

Thirty years ago, when the author delivered what he believed was the first lecture upon such a subject, many founders thought—and he himself was of the same opinion—that the study and experiments which had been undertaken in connection with the facing of moulds had almost reached their limit, and that there was very little room for improvement, particularly when one noted the perfectly good castings which were then being turned out. There was, however, one thing which was overlooked, and that was the growth of competition, the production of larger and heavier castings, and the necessity of adopting methods which, while effective and complete, would reduce the cost of application and still give more efficient results than were at that time obtainable.

The charge of rule-of-thumb practice often made against those old-time workers was somewhat justified. They dealt with the question very sketchily, and it was not until they co-operated by forming the Institute of British Foundrymen and the British Cast Iron Research Association that they regarded the makeshift ideas then in vogue as unreliable and haphazard.

Experts Disagree

There is apparently, even to-day, quite a gulf between the opinions of some of the investigators who have undertaken researches into foundry facings. A very clever research worker not long ago declared that all graphite, as the best refractory known, was of a flaky character. That is definitely not the case, as there are certain forms which are the reverse of flaky, showing themselves in powder form with a distinct globular shape. That graphite makes one of the best facings for iron castings, if not the best, goes without saying, but it is considerably more expensive than some other forms of refractory, and, therefore, is not used to the extent that would be the case if its cost were lower.

The subject of foundry facings may be divided into three parts, because the term "facing" not only applies to the actual face of the mould, but also to its general composition and the correct manipulation of cores, which, in their turn, require to be very carefully handled with due regard to permeability and comparative imperviousness to moisture.

In spite of a study extending for considerably more than a quarter of a century, it is still impossible to enunciate any hard-and-fast rules which should be held as binding over all sorts and conditions of castings. On the contrary, experience dictates that attempts on the part of either technical or practical experts to dogmatise in this way are foredoomed to failure. If there be one particular trade in the universe in which it is next to impossible to lay down definite rules, definite theories, or definite formulæ which shall be held to govern each and every phase of practice, that trade is ironfounding. Even the weather seems to conspire to add to the problems of the foundryman.

The Ideal Sand

The basis requirement for a mould is sand, and if it were possible to procure in all parts of the world an ideal sand, it would be scarcely necessary to introduce facings at all; but the ideal sand is to all practical intents and purposes unprocurable, and therefore facings are necessary. There follows in this train of thought the production of facings of various kinds suitable for different classes of castings. According to the late Dr. Moldenke, the well-known foundry metallurgist, an ideal sand should consist of rounded, uniformly-sized grains of silica, each grain to be evenly coated with the thinnest layer of the most refractory and fattest clay to be had. It is easy to understand what is meant. One of the principal bugbears of the moulder is the proper venting of the mould. If it were possible to obtain perfectly rounded grains of sand instead of the angular and irregularly-formed grains with which they have to deal, and if these rounded grains were coated with an infinitesimal amount of clay, not only would the mould itself be exceedingly refractory, but it would be most excellently vented because of the interstices between the round grains.

As long as moulding sands remain so variable, it is impossible to point to any royal road to perfect castings, except on the lines that have heretofore, in a more or less degree, been adopted by our forefathers. It is not meant by that, however, that foundrymen are slavishly to copy the methods of their forbears.

Nature of Auxiliary Agents

Practical experience has taught the moulder that with the varying of sands, some auxiliary agent is required to ensure the most satisfactory results, not only with regard to the skin of a casting, but also to assist in the prevention of blowholes and other blemishes. To-day, the moulder has a wide selection of facings to choose from, and there is no necessity for him to experiment—often a costly method—as to which of the qualities should prove most satisfactory for his purpose.

It is well known that, for iron casting, carboniferous facings are best suited as against the siliceous refractories used by the steel-founder. The carboniferous facings are divided into several groups. Possibly, the best known is the graphitic substance called plumbago. The most suitable for foundry work is that from Ceylon, where plumbago mining forms probably the most important industry in the island. In this product, a carbon content can be obtained as high as 95 per cent., but, of course, there are many lower grades, and the cost rules accordingly. Generally speaking, it is not usual to find this commodity used except for the best green sand in foundries, and as the demand for good castings is maintained and the price of castings has a tendency to become lower, it naturally follows that the founder looks about for something which, while carrying all the attributes for non-fusibility of plumbago, might be obtained at a lower cost.

"Patent" Facings

The prohibitive cost of plumbago has led foundry-facing manufacturers to turn their attentions to a substitute. As a result there are now on the market many forms of "patent" blackings, for which is claimed the refractoriness of plumbago, coupled with the fusibility of charcoal, and its power of adherence when sleeked or dusted on the mould or placed there in the form of a liquid wash. For many of these materials it is claimed that no adjustment is necessary to give them the required adhesiveness, coupled with high refractoriness, but on this point opinions diverge, and it is almost impossible to produce a facing upon which half-a-dozen practical individuals would express absolute unanimity. The reason for this is the variation in actual practice between individual shops, and so long as this divergence of opinion continues, so long will it be impossible to lay down any definite rules for the guidance of the moulder.

If the carbon content of the blacking was the only point to be considered, the situation would be much simpler than is actually the case. The nature of the mould, the class of casting, the condition of the various sands, and other details are all to be borne in mind, and it will be readily understood that with these constantly changing conditions, it became necessary to provide blackings of different strengths, different textures and different grists.

Use of Vitreous Enamelled Finishes

When vitreous enamelling was still at the difficult period, and considerable trouble was experienced in getting the enamel to run evenly over the surface of the finished casting, experiments proved that this was due to the action of one of the ingredients in the blacking, and it was not until after long and continued research that the trouble was eliminated. At the present time, the facing being used for vitreous-enamelled baths is proving highly effective, and will be incapable of improvement for some considerable time to come. The carbon content of this blacking, however, is not nearly so high as some of the other grades, and this point bears out the fact that, although a high percentage of carbon is essential if some castings are to strip cleanly, there are other jobs which require to be treated with a mixture of various ingredients, each of which shall in its own particular way assist the moulder in his efforts towards securing a mould which will be affected by heat to the least possible extent, and thus obtaining a casting which will reduce the fettling costs.

Is Coal-Dust Necessary?

American foundrymen, when speaking of the question of refractories, often mystify British *confrères* by their references to sea-coal facing, and it is still not generally known that they are simply referring to coal-dust. There is at the moment some controversy as to the necessity of using coal-dust at all, and some experiments have been made which have led individuals to decide in their own minds that coal-dust in moulds for the foundry is superfluous. That may be so in certain circumstances, but for general practice and for reasons which have been previously indicated, it is difficult to believe that all kinds of castings could be produced without the use of coal-dust. The varying conditions existing, the diverse sands, the ranges of thicknesses, etc., have all to be considered, and it will be admitted that much closer attention to detail is demanded when using plain sand than when the usual adjuncts are brought into operation according to ordinary practice.

Action of Coal-Dust

(The lecturer then exhibited five plate castings he had made in the course of his experiments, one of which, he said, could justly be claimed as being "the perfect casting.")

In these experiments, ordinary Wolverhampton sand was used, and it was sieved, dressed and prepared in the manner customary in foundries throughout the country. The black sand was ordinary floor sand, containing a certain proportion of coal-dust in various stages of decomposition. The castings were made from wooden patterns 8¼ in. by 8¼ in. by ½ in. Each of the moulds was made in the same manner, and not vented. From the results, it was reasonable to conclude that when the gas was generated rapidly, there was a conflict raging between the live metal and the volume of gas, which forced its way along the face of the sand and metal and out at the joint, this being the line of least resistance. The moment the mould was full, the gases came through the joint and fired instantly, there being no time for the gases to travel through the pores of the sand and out of the joint. Therefore, they must have come along the face of the metal. The distance from the edge of the moulding box was only 1¼ in., and this made a very easy channel for the escape of gas, although the top part of the box fitted closely to the bottom part and so sealed the joint. Whilst there might have been room for the gas to escape, it did not follow that the live

* Paper read before the Falkirk Section of the Institute of British Foundrymen, Mr. R. R. Shaw presiding.

metal could force its way through the same aperture.

It is only reasonable to conclude that, while the gas generated from the coal-dust is passing between the live metal and the face sand of the mould, it is doing its work, namely, that of providing a protective barrier by forming a film of carbon from the decomposed coal-dust on the face of the mould. This leads to the assumption that the provision of good-class coal-dust, of a proper grist and carefully graded, tends to produce a casting of far better appearance than when sufficient care is not exercised and makeshift materials are used.

When coal-dust is used in proper proportions, it most certainly makes a wonderful difference to the face of the casting, and in cases where it is not used, the casting presents a very harsh and grey appearance. On the other hand, it is just as essential to guard against the excessive use of coal-dust. Castings can gravely deteriorate when irregular proportions of sand and coal-dust are used.

Coal-Dust and Venting

The author's experiments have caused him to modify his original belief that the coal-dust assisted to a considerable extent in forming a vent through which the gases might escape. This may be the case to a lesser extent, yet the venting of a casting depends principally upon the moulder, and not on the extraneous assistance of coal-dust. This brings one to the conclusion of the old practical moulder who declared that molten metal rushing through the mould causes a film of gas to form, which protects the sand, and which provides the attractive blue skin on the face of the casting.

Another important matter which the moulder has to consider is the grist of the coal-dust he uses. After many tests, it was concluded that, with the heavier castings, the coarser should be the grist, because of the greater heat that will be generated by the greater mass of the metal. It naturally follows that the formation of gas will be more pronounced, but this is satisfactorily taken up, as it were, by the fact that there is a much heavier body of metal, and the pitting, which would otherwise take place, is, with the thicker casting, non-existent. It does not follow, however, that coarse coal-dust will give the same result if the castings are much heavier, and there is a full flow of metal at a high temperature. The author has seen castings poured into a mould made up of very coarse coal-dust with sand and which stripped excellently without the slightest sign of pitting. If it were possible to obtain an ideal sand, of which the refractory quality and permeability were of such a precise nature as to permit of exact standardisation, the provision of coal-dust might not be necessary, but, failing this premise, some aids have to be called in from outside, and practical experience for many years has proved to the foundrymen that the addition of coal-dust is most satisfactory so far as the finished article is concerned.

Grading of Coal-Dust

One is accustomed to hear coal-dust described as superfine, fine, fine medium, medium coarse, and coarse. What do these descriptions mean? Is there a particular standard of mesh through which these various grists may pass? It is to be regretted that, except in one or two instances, manufacturers have not definitely established demarcation. This emphasises very clearly the necessity for a little more co-operation between the user and the supplier. As a matter of fact, the founder has the matter in his own hands. If he demanded a certain grist, the manufacturer would be compelled to supply that need, and if the finished article did not conform to sample, then the course for the founder to adopt is clear.

The secret of sucessful facings is the blending of certain refractories in such a way as to meet the variable requirements for different foundries, different castings, different temperatures, and different temperaments. This is not an easy task, but it is one which, in the light of present-day research, is not altogether unattainable.

DISCUSSION

MR. R. BALLANTINE (President of the Scottish Branch), remarking that some people wondered if the castings made by the old artisans could be bettered, said he had passed that stage, and could say quite definitely that they could be. One had only to recall the old motor-car cylinders made by the unskilled men of the past, and components produced by mechanisation. The system evolved through many decades was improving as time went on. Speaking of facings, he said that founders were very much inclined to blame the suppliers when things went wrong. They should really condemn themselves, and say quite distinctly that it was through their own incompetence that they did not correctly use the materials which the suppliers offered.

MR. N. A. W. ERSKINE respectfully submitted that Mr. Winterton's " perfect " plate was not a perfect plate. His own experience was that one got nowhere by judging from the face of a fine casting. He felt that the less blacking the foundry used the better results obtained, and as to coal-dust, he thought it had a better chance if it was properly incorporated. He asked if Mr. Winterton had carried out any experiments in regard to general furnace pans. These were the bane of Falkirk. Experiments had shown that if blacking was eliminated, and if made with a certain sand, a first-class job was secured. The trouble, however, was to ensure good running. Did Mr. Winterton agree that the use of blacking or coal-dust increased the flowing power of the metal in the mould?

MR. WINTERTON first of all disclaimed that the specimen he had shown was a " perfect " casting. He himself, he said, did not regard it as such, and very probably the " perfect " casting did not exist outside of each of their own individual foundries. He admitted that furnace pans were a matter about which he was rather diffident of speaking in Falkirk. He had experimented, and he did not think that one could cast a furnace pan so successfully without a certain amount of facing. Sometimes, however, blacking was put on too frequently, with the result that the furnace pan was over-blacked—which was as much a mistake as being under-blacked. As regards flowing, however, he had found that this was definitely improved in cases where the facing had been sleeked.

The meeting closed with MR. R. R. SHAW (chairman) moving a vote of thanks to the lecturer, and to those who had taken part in the discussion.

Iron and Steel Production

The British Iron and Steel Federation reports that there were 76 furnaces in blast in the United Kingdom at the end of October, compared with 77 furnaces at the end of September, three furnaces having ceased operations during the month, and two having resumed production. The production of pig-iron in October totalled 469,400 tons, and included 94,700 tons of hematite, 269,200 tons of basic, 79,900 tons of foundry, and 11,600 tons of forge pig-iron. The October figure compares with 429,800 tons in September last, and 769,600 tons in October, 1937. Steel output in October, at 854,800 tons, showed an advance of 100,100 tons over September. There were the same number of working days for steel in both months. This represents a greater increase than any movement between September and October recorded over the past ten years.

By the end of October, 24 more open-hearth furnaces had come into operation compared with a month earlier, and 29 more compared with the close of June.

Chilled Iron and Other Rolls

(*Concluded from page* 370.)

Temperature and Fluidity

A MEMBER referred to Mr. Allison's coloured slide as a new departure. In comparing the results secured by the old makers of rolls and those forthcoming to-day certain factors must be considered. One was that the standard of chilled rolls had gone up considerably in the last few years. People who had been in the trade a long time talked of the hammering up of pinholes, a thing which would not be permitted to-day. Mr. Allison imagined that there was not much scope for specially grained rolls, but the variety of rolls nowadays was an extensive one.

An American firm recently stated that they were manufacturing 45 different types of rolls. His opinion was that the ordinary grain roll would slowly go out, and in time all would use specially grained rolls—rolls containing alloys in some proportion. In America they had gone to as much as 4 per cent. nickel and chromium. He endorsed Mr. Allison's remarks about the microscope, and asked if he had any idea whether chromium up to about 0.4 per cent. did increase hardness to any extent. In regard to the spread of mottle, in certain circumstances he had encountered small proportions of mottled iron and in other cases large proportions of mottled iron. He knew alloys would do that, but he was referring to straight chilled rolls. Referring to the point raised concerning the pyrometer and eyesight, he thought that by using his eyes the caster got more than the actual temperature. It gave him some idea of fluidity as well.

Influence of 0.4 per cent. Chromium

MR. ALLISON replied that the microscope did not tell him whether it was a bad roll or a good one. The standard of rolls had been greatly raised in recent years. A roll was either good or bad, and if there was one pinhole in it it must be machined to see if it would come out. Grained rolls lasted a long time—as much as four or five years. He had made nickel-chromium rolls. He did not think chromium itself hardened very much, and thought it depended upon the carbon content. Up to 0.4 per cent. chromium did not harden very much. Mottle sometimes spread and sometimes did not; as a rule, the lower the carbon the greater the spread of mottle.

In reply to Mr. J. Hird, MR. ALLISON said he had seen the phenomena of an internal chill, but not in chilled rolls. Answering other members, Mr. Allison said that in turning a roll little bits of chill might flake off, but they were well below the surface. The best English firms did not use phenalium, which was used by American makers of cast rolls.

On the proposition of MR. COOK, seconded by MR. HARRIS, a hearty vote of thanks was accorded Mr. Allison for his address.

Book Review

The Complete Welder. To be published in about 30 weekly parts, by George Newnes, Limited, Tower House, Southampton Street, Strand, London, W.C.2. Price 1s. each part.

A high standard has been set by Part I of this series, and judging from the list of promised contributors there is every reason to believe that it will be maintained. The contents include articles on oxy-acetylene high-pressure welding, principles of both arc and resistance welding and spot welding machines. Finally, there is a description of a popular type of arc welding plant. The magazine is profusely illustrated. In order to maintain reader interest, portions of the ultimate three volumes are being published in each weekly part.

Improvement of Cast Aluminium-Magnesium Alloys by Additions of Beryllium and Titanium*

By GASTON GAUTHIER†

Aluminium-magnesium alloys containing up to 12 per cent. of magnesium are of very great importance on account of their high corrosion-resisting properties, irrespective of the heat-treatment to which they have been subjected. Unfortunately, the presence of a certain quantity of magnesium causes the surface of the molten bath of metal to oxidise very rapidly. This is not very detrimental when the metal is in a furnace or crucible, because oxidation can then be prevented by means of a suitable flux, but it is much more troublesome when the metal is being poured, for example, in the case of casting in sand, because an oxide film is formed whenever the metal comes into contact with the air, oxidation taking place more rapidly, the higher the magnesium content of the alloy. Due to the eddies which are almost always produced in foundry moulds, the oxide film‡ mixes with the metal and forms zones of brittleness or porosity. This is still more troublesome when the alloys are cast under pressure.

The disadvantage is obviated by modifying the atmosphere of the moulds and by introducing substances which counteract the oxidation of magnesium. Sulphur, certain fluorides, etc., are used, being either mixed with the sand in the case of casting in sand or injected in the case of pressure die-casting. Although such mixing is generally quite simple, it constitutes an additional difficulty which it should be the aim to avoid.

Finally, in the course of the heat-treatment necessary for imparting the maximum characteristics to these alloys, the surface oxidises strongly, becoming blackened, especially in air furnaces. Two disadvantages make themselves felt: the surface becomes poorer in magnesium (although it is true that this provides an additional protection against corrosion), but the very unpleasing appearance in particular necessitates additional surface treatment, such as shot-blasting.

For some time, the attention of investigators has been devoted to discovering substances to be added to the alloys with a view to obviating these disadvantages, the addition of calcium having been proposed for example. Its influence in diminishing oxidation is incontestable, but it has the disadvantage of considerably reducing the rate of solution of the Al_3Mg_2 compounds during the homogenising treatment, and consequently of requiring a very lengthy heat-treatment for alloys having a magnesium content of more than 8 per cent., which is not compensated very satisfactorily by an addition of lead.

The author has endeavoured to ascertain what other additions would diminish oxidation. For purposes of comparison, a parallelepiped ingot weighing about 5 kilograms was cast in each case. The upper surface in contact with the air and the lateral surfaces in contact with ordinary moist sand (green-sand casting) were observed. The only additions which gave appreciable results are the following, arranged in increasing order of importance:—

Zirconium.—The introduction of 0.2 per cent. of this metal provided a casting having decidedly fewer oxide and nitride excrescences on the upper surface (in contact with the air) than castings without an addition of zirconium. The same applies to the oxidation blisters on the lateral surfaces (in contact with the sand). The surface of the molten metal in a crucible, on the contrary, oxidises as much as the metal not containing added zirconium.

Boron.—With 0.1 per cent. the influence is much greater than that with 0.2 per cent. of zirconium. There are only a few excrescences on the upper surface and few blisters on the sides. The same remarks as those made above apply to the surface of the molten metal.

Titanium.—A matter of 0.1 to 0.2 per cent. of titanium is sufficient to cause the casting to exhibit only a few rare excrescences on the upper surface. There are no blisters on the sides. As in the case of boron and zirconium, there is no protection at all against oxidation of the molten metal.

Influence of Beryllium on the Oxidisability of Al-Mg Alloys at High Temperatures

Of all the metals added, beryllium is the most active and really imparts to Al-Mg alloys an appreciable resistance to oxidation at high temperatures, both in the solid state and liquid state. For that reason, the investigation of this addition has been carried to an advanced stage.

Protection of Metal against Oxidation and Nitride Formation during Solidification in a Sand Mould

A first experiment was made to determine the minimum quantity of beryllium which still had a marked effect when the alloys were cast in the parallelepiped ingots described above. Additions of about 0.2 per cent. of Be were made to alloys containing 7 per cent. and 12 per cent. of Mg by adding the double fluoride in a suitable quantity on the surface at a temperature between 700 and 750 deg. C. Al-Mg alloys with 7 and 12 per cent. of Mg and containing gradually diminishing amounts of Be were then prepared by using the first two alloys as master alloys of beryllium.

All the alloys were cast in moulds as identical as possible and at the same temperature, namely 720 deg. C., and it was found that even with an addition of only 0.01 per cent., the ingot cast in sand does not exhibit any blisters on the sides nor sweating or cauliflower tops on the upper surface. This surface after cooling is yellow, brown or black, but this film of nitride is very thin, being removed by gentle sand-blasting or pickling. The appearance of the surfaces is darker, the more magnesium and the less beryllium contained in the alloy. With 0.02 per cent. beryllium, the surface of the 12 per cent. magnesium alloy is brown. This concentration appears to be the minimum concentration to be adopted with regard to protection.

Protection of Molten Metal Against Oxidation

In preliminary experiments, the author endeavoured to ascertain the minimum Be content which imparts adequate resistance to oxidation in molten baths. The figure of 0.02 per cent., already found for the protection of the metal cast in green sand, is also to be noted in this case. To show the protective influence of beryllium on molten baths, the process was as follows:—

Alloys having magnesium contents of 7, 10 and 12 per cent. were melted and maintained at a temperature of about 750 deg. C. No flux was placed on the surface of the metal, so that oxidation and nitride formation were quite free. The total period of standing was 1½ hours at 750 deg. C., and the amount of oxide formed after ½ hr., 1 hr. and 1½ hrs.' standing was weighed and the magnesium remaining in the bath after standing for 1 hr. was determined. The same experiments were made with alloys containing 0.02 per cent. of Be and with alloys containing no addition.

As will be gathered from Table I, the weight of oxide is decidedly diminished by the presence of beryllium, the effect being greater, the higher the magnesium content of the alloy. The presence of 0.02 per cent. of beryllium causes an alloy containing 12 per cent. of Mg to oxidise less than an alloy containing 7 per cent. of Mg without an addition of Be.

Concerning the loss of magnesium, it will be seen that an addition of only 0.02 per cent. of beryllium is sufficient to suppress such loss completely. It would appear that, due to this addition, the oxidation of the bath proceeds in proportion to the quantities of the metals Al and Mg present, and that everything takes place as if the magnesium did not oxidise any more rapidly than the aluminium.

Protection during Heat-Treatment

During heat-treatment, castings of Al-Mg alloys heated in an air furnace become covered during the period necessary for the solution of the Al_3Mg_2 compound, at about 425 deg. C., with an oxide film of displeasing appearance, the colour varying from grey to black. Alloys containing 0.02 per cent. of Be assume an almost golden tint, indicating that oxidation has been almost completely suppressed.

Influence of Beryllium on Crystallisation

Unfortunately, although the action of beryllium on oxidisability at high temperatures is very considerable, its action in increasing the coarseness of crystallisation is just as great. Two identical specimens were cast in sand under the same conditions, one without any addition and the other with 0.02 per cent. of beryllium. The first had crystals of only a few tenths of a millimetre in diameter, while the second exhibited crystals of at least 5 or 6 millimetres in diameter, or even larger. It is to be expected, and has been easily confirmed, that such crystallisation involves an increase in the duration of the heat-treatment and also a very definite reduction in the mechanical properties.

TABLE I.—*Influence of Be and Time on the Oxidation of Mg Content.*

Mg content per cent.	7	7	10	10	12	12
Be content per cent.	0	0.02	0	0.02	0	0.02
Mg content remaining after standing 1½ hrs.	6.95	7.02	9.10	10.03	11.18	12.08
Weight of oxide at the end of ½ hour	0.25	0.24	0.72	0.18	1.45	0.17
Weight of oxide at the end of 1 hour	0.02	0.015	0.04	0.02	0.30	0.015
Weight of oxide at the end of 1½ hours	0.02	0.10	0.04	0.015	0.065	0.015

This effect is not very perceptible as long as the temperature attained on remelting the alloy is comparatively low. Irrespective of the additions of Be between 0.04 and 0.01 per cent., the properties of an alloy containing 12 per cent. of Mg, the remelting temperature of which does not exceed 750 deg. C., will be of the following order: Tensile strength between 23 and 24 tons per sq. in., elongation between 14 and 19 per cent. If, however, the remelting temperature rises to 900 deg. C., the tensile strength drops to 19.6 tons per sq. in. and the elongation to 5 per cent. Actually, a solution treatment longer than the normal treatment would have greatly increased these figures.

Additions of Grain-Refining Elements

To obviate these disadvantages due to the presence of beryllium, the author endeavoured

* Paper read before the Polish International Foundry Congress.
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‡ There is, furthermore, simultaneous formation of oxide and nitride.

to discover additional elements for recovering the normal size of grain and mechanical characteristics of alloys not containing added beryllium. Numerous additions were made, of which only those of zirconium, vanadium and titanium will be mentioned.

The influence of zirconium, which is very considerable in the case of alloys on a magnesium basis to which beryllium has been added (in this connection, a German Patent Application has been filed by the Compagnie A.F.C.) is not only ineffective in the case of Al-Mg alloys, but is rather fatal. Vanadium has a marked action on the crystallisation and on the mechanical properties, but the action is quite inadequate. Titanium, on the contrary, has a very powerful action, and the following is mainly an account of the investigation of this addition.

For examining the influence of Ti, cast specimens of an alloy containing 12 per cent. of Mg and 0.02 per cent. of Be were prepared and heated for ¼ of an hour at 800 deg. C. so as to produce a coarse grain. The mechanical characteristics after heat-treatment were:—Tensile strength 22.8 tons per sq. in. and elongation 10 per cent. After the addition of 0.05 per cent. of Ti, the grain was as fine as for an Al-Mg alloy without additions and the tensile strength was 24.4 tons per sq. in. and elongation 12 per cent.

TABLE II.—*Influence of Remelting on Mechanical Properties.*

Addition of Ti.	0.08 per cent.		0.05 per cent.		0.02 per cent.	
	Tensile strength. Tons/sq. in.	Elongation. Per cent.	Tensile strength. Tons/sq. in.	Elongation. Per cent.	Tensile strength. Tons/sq. in.	Elongation. Per cent.
1st melting	25.1	14	24.6	14	24.4	14
2nd melting	25.9	11	24.2	15	25.1	15
3rd melting	23.3	11	24.8	13	24.8	13
4th melting	—	—	24.7	15	24.9	15

To ascertain whether the influence of titanium persists during successive remelting operations, different alloys containing 12 per cent. of Mg and 0.02 per cent. of Be and 0.1 per cent. of Ti were remelted several times. Taking the mean, it was found that the alloy of the first melt had a tensile strength of 25.0 tons per sq. in. and an elongation of 15 per cent. After a first remelting, the tensile strength was 23.2 tons per sq. in. and the elongation 9.8 per cent. After another remelting the tensile strength was 20.9 tons per sq. in. and the elongation 7 per cent. Micrographic examination shows the familiar phenomenon of the concentration of the titanium in coarse crystals, the increase in the size of which in the course of the successive remelting operations is the cause of the diminution in its effect.

It was therefore necessary to introduce a fresh quantity of titanium at each remelting operation. Some experiments made with the object of perfecting a method of introduction showed that introduction by the action of potassium fluortitanate on the surface of the molten metal is difficult to employ, because this salt reacts mainly with the magnesium and an infusible compound is formed at the commencement, so that the reaction is arrested. The simplest method was found to be to add the titanium in the form of a carefully proportioned aluminium-titanium stock alloy.

For the purpose of ascertaining the quantities of titanium to be added at each remelting operation, numerous alloys containing 12 per cent. of Mg and 0.02 per cent. of Be were subjected to successive remelting operations. In one series, 0.08 per cent. of Ti was added at each remelting operation, in another series 0.05 per cent., and in a third 0.02 per cent.

The results are reproduced in Table II, and show that an addition of 0.02 per cent. is sufficient, because, apart from the fact that the mechanical properties remain very good, the grain is always at least as fine as for alloys containing neither beryllium nor titanium.

Furthermore, this amount of 0.02 per cent. of Ti added at each remelting operation leads in practice, in a foundry employing such additions, to a permanent Ti content of less than 0.08 per cent. According to micrographic examination, however, the crystals rich in Ti, which by their fragility diminish the mechanical properties of the alloys, only appear above 0.1 per cent. of titanium. This proportion of titanium is therefore quite suitable.

Introduction of Beryllium and Titanium

These two elements may be added to the aluminium serving as basis for the preparation of the alloy, but it will be preferable to add them in the form of a stock alloy. In the case of beryllium, this is the most economic method, and in the case of titanium it is the only possible method, as salts such as titanium, fluoride, potassium fluortitanate, etc., do not react very well on account of the magnesium in the alloy.

Influence of Beryllium and Titanium on Corrosion

The author investigated the behaviour of alloys containing 7 and 12 per cent. of magnesium and 0.02 per cent. of beryllium and 0.05 per cent. of titanium to corrosion by salt mist. The observations made up to the present indicate that these alloys corrode as little as the alloys without additions, that is to say practically not at all.

Conclusion

This investigation shows that an addition of 0.02 per cent. of titanium at each remelting of an Al-Mg alloy containing 0.02 per cent. of beryllium fully compensates the action of the latter metal in increasing the size of the grain, and that by means of these two additions it is possible to produce alloys which represent a considerable advance over alloys prepared without these additions, due to the resistance to oxidation in the molten state and also to their resistance to oxidation in the presence of moist moulding sands. These alloys are undoubtedly of interest for use in machines for casting under pressure.

Publication Received

The Technical Report of the British Engine Boiler and Electrical Insurance Company, Limited. Published from 24, Fennel Street, Manchester. Price 7s. 6d.

Though this Report is not so voluminous as in years gone by, its technical worth has increased, and especially is the reviewer appreciative of the twenty pages or so of matter relative to the interpretation of the notched bar test. It is hoped that there is some real significance in the fact that no failure of a casting is reported, whilst a decade ago there were many!

Aluminium Works in Wales

The South Wales Aluminium Company, Limited, registered a few weeks ago with a capital of £500,000, has now completed negotiations with the Rheola estate in the Vale of Neath, Glamorgan, for the acquisition of 200 acres of land above Resolven, for the erection of a new aluminium works. When completed the works will give regular employment to 600 men.

Symposium on Gas Temperature Measurement

At the Lecture Theatre of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, a Symposium on Gas Temperature Measurement will be held on Friday, December 2. The Symposium will open at 10.30 a.m., and there will be an interval for lunch from 12.30 to 2.30 p.m., when the second session will commence. Lieut.-Colonel J. H. M. Greenly, C.B.E. (President of the Institute of Fuel), will open the meeting. Sir Frank Smith, K.C.B., F.R.S., will take the chair at the morning session, and Sir Henry Tizard, C.B., F.R.S., will take the chair at the afternoon session.

The following is a list of the authors and the Papers which they will present.

Morning Session.—(1) "The Temperature of a Gas—its Meaning and Measurement," by J. G. BENNETT and M. PIRANI. (2) "The Errors in Gas Temperature Measurement and Their Calculation," by M. FISHENDEN and O. A. SAUNDERS. (3) "The Wall Effect in Gas Temperature Measurement," by C. H. BOSANQUET. (4) "The Measurement of Flame Temperatures," by G. RIBAUD, Y. LAURE and H. GAUDRY. (5) "The Theory and Application of the Suction Pyrometer," by A. SCHACK. (6) "Optical Temperature Measurement of Luminous Hydrocarbon Flames," by G. NAESER. (7) "Metallic Materials for Thermocouples," by A. SCHULZE. (8) "The Measurement of Temperature in High-Pressure Containers," by A. MICHELS and B. BLAISSE.

Afternoon Session.—(9) "A Modified Aspirating Thermocouple for Gas Temperatures," by B. M. LARSEN, G. SIDDALL and K. HEINDLHOFER. (10) "Errors in Gas Temperature Measurement," by A. F. WEBBER. (11) "The Measurement of Temperature of Producer Gas," by M. W. THRING. (12) "The Measurement of Gas Temperature in Glass Furnaces," by M. PARKIN. (13) "Gas Temperature Measurement in Boilers," by W. R. HAWTHORNE. (14) "Gas Temperature Measurement in the Chemical Industry," by J. C. SWALLOW. (15) "Application of Temperature Measuring Equipment to the Measurement of Gas Temperatures," by S. MATTHEWS. (16) "Temperature Measuring Instruments," by W. BOWEN.

The Papers will not be read at the meeting, but Reporters will give a brief summary of the Papers to be discussed at each session.

Book Review

Praktisches Handbuch der gesamten Schweisstechnik. Vol. 1.—Gasschweiss und Schneidtechnik (Practical Handbook of General Welding Technique. Vol. I—Gas Welding and Cutting.) (Third Edition.) By Prof. Dr. Ing. P. Schimpke and Ober Ing. Hans A. Horn. Published by Julius Springer, 22-24, Linkstrasse, Berlin, W.9. Price 18 marks.

This book is the third edition, rewritten and enlarged, of the first volume of a handbook on welding technology, dealing with gas welding and cutting, originally issued in 1924. The introductory section gives a brief account of the metallurgy of cast steel, malleable cast and grey cast iron and the non-ferrous metals, great significance being attached, rightly enough, to the importance of the metallurgical aspects of welding. The second and third parts deal with gas welding and cutting from every angle, and while steel naturally gets most attention, sections deal with the welding and cutting of cast steel, malleable cast and grey cast iron, and the non-ferrous metals. As a text-book the work is comprehensive and well illustrated, and is to be recommended. J. G. P.

Refinement of the Structure of Castings

A GENERAL REVIEW OF THE PRESENT SITUATION

By Prof. A. PORTEVIN (Director, École Supérieure de Fonderie)

(*Continued from page* 356.)

This refining of the grain of a metal by the addition of other metals has been connected by K. Iwase, J. Asato and N. Nasu with the appearance of a peritectic reaction for the alpha alloys of copper with iron and cobalt. There is a sudden reduction in the size of the grain when the content corresponding to the end of the horizontal eutectoid line has been reached and surpassed. This has also been verified for the ternary alloys derived from the latter by addition (Al, Zn, Sn, Ni, etc.) and also, although to a less pronounced degree, for other alloys having a peritectic reaction: alloys of copper with Sn, Si and Zn, alloys of silver with Cd, Zn and alloys of Sn-Sb and Al-Ni. It must be concluded that the crystal which exists before the peritectic reaction is fractionated when it reacts on the liquid. More generally, however, for explaining the refining of the grain by additions, the formation of fine precipitates acting as centres of crystallisation is invoked. Strictly speaking, there is no direct proof of this. The alloy would have to be compared with the same alloy freed from suspended particles by centrifuging, all other solidification conditions remaining the same.

This naturally takes the subject to the refinement of the grain by the artificial introduction of nuclei into the liquid before solidification. Such introduction may be: (*a*) direct, and (*b*) indirect, that is to say, resulting from a reaction or precipitation in the body of the liquid.

(a) Direct Introduction

Solid particles of the substance which is to crystallise are projected during solidification or are incorporated before solidification. Solution first of all occurs at a rate depending on the size of the solid particles introduced, the agitation and the temperature of the liquid bath. The effect on the crystallisation will therefore depend upon the size of these particles, the temperature of introduction and the time elapsing up to the temperature at which solidification commences. On the other hand, solution should be so far advanced that only microscopic or ultramicroscopic particles remain.

Consequently, the dimensions of the pieces, fragments, bars or wires which are placed in the mould[15] or which are thrown into the molten metal during pouring are regulated. If necessary, the solid metal is protected from oxidation. The quantity may vary from a few per cent. to a few tenths per cent. E. Scheil (Zeitschr. Metallk., 229, August, 1936) has shown that there should be a definite relationship between the thickness of the wire and that of the ingot for ensuring the best refinement of structure.[16]

(b) Indirect Introduction

It is possible to produce in the body of the liquid the formation of a precipitate of particles or "inclusions" playing the part of nuclei or centres of crystallisation. For example, the addition of reducing agents such as Al or Si to a metal bath containing oxides in solution (FeO in Fe, Cu_2O in Cu) produces the formation of inclusions of SiO_2, Al_2O_3, silicates, silico-aluminates, etc.

It is impossible here to enter upon a discussion of these non-metallic inclusions as it would be necessary to examine their nature, form, fineness, etc., which vary according to the entire thermal and chemical history of the metal bath. In this connection, reference should be made to the recently published work on the morphology of inclusions.[17] It will suffice to recall that the addition of a reducing or oxidising element may not only cause the formation of fresh inclusions, but may react on the existing inclusions and bring about either their coalescence and hence a reduction in the number of nuclei, or inversely the dismemberment of existing inclusions into a finer dust and thus lead to an increase in the number of nuclei.

Thus, the addition of aluminium to a metal, steel or cast iron, containing inclusions of silicates of manganese or aluminium in more or less fine particles, subdivides them into very fine particles grouped in more infusible bunches or accumulations of alumina.[18]

These phenomena may, of course, also exert their influence on the primary graphitisation of cast iron, as the author has pointed out on a previous occasion,[19] although a direct proof of this has not yet been furnished.

Furthermore, generally speaking, it may be said that a variation either of concentration (of the reducing agent or dissolved oxide) or of temperature may result in the appearance, or inversely the disappearance, the coalescence or inversely the subdivision, and consequently the deposition or inversely the maintenance in suspension of the inclusions, while at the same time being able to modify their nature.

It will be appreciated from the above that this conception of the inclusions as nuclei of crystallisation (or graphitisation of cast iron) may be interpreted in various ways. As a practical consequence, starting from this idea, it is possible to add simultaneously an oxidising and reducing agent. Thus, quite recently, the solidification structure of grey cast iron has been refined by adding simultaneously, for example, silico-calcium and sodium carbonate or dichromate (A. Portevin and R. Lemoine, C.R., 1936, 203, 237). Very fine graphite and very strong cast iron is obtained in this way.

According to some authors (V. Keil, Mitschke), this function of precipitating the graphite only belongs to the particles of silicates of iron, but they only give an indirect proof based on the fact, observed by them, that this effect occurs when oxide of iron and silica are present simultaneously, but the result mentioned above does not appear to require this hypothesis. In any event, this consideration of artificial nuclei, either like those formed during solidification or different from them, may provide very valuable processes for refining the solidification structure and consequently the mechanical strength of cast metals and alloys. The efficiency of this action depends upon the aptitude for undercooling possessed by the material itself. In the case of high-silicon irons which consequently do not exhibit any tendency to undercooling, the effect is not produced, and according to Norbury and Morgan (Iron and Steel Inst., 1936) even the premature introduction of nuclei may, in this case, produce a coarser structure.

Chemical action may be exerted not by the addition of another element to the metal but by the action of a flux or slag which is immiscible with the liquid bath and consequently forms with it two liquid phases. An equilibrium tends to be established between these two phases and therefore there is an exchange of elements between them. The slag is therefore able to absorb elements or inclusions from the metal bath (and thus de-oxidises or desulphurises the steel), or conversely it may serve to introduce elements into the metal (and it is possible in this way to add to the steel bath manganese, silicon, chromium, tungsten, etc.), while at the same time it may serve to protect the metal from the atmosphere. It will therefore be appreciated that the solidification structure of alloys and the graphitisation of cast iron may be modified by the action of a flux or slag, and this chemical action may be considerably accelerated by mixing the two phases together (Ugine-Perrin process).

It will thus be seen that there is available a large number of methods of influencing the solidification structure. Some of these are as yet little known or studied while for others the rules of application have yet to be defined. There is a vast and interesting field still to be explored by the investigator.

SUPPLEMENTARY NOTE

Case of a Polymorphous Transformation: Steels

As stated, no discussion will be given of the change of structure or grain by the effect of a polymorphous transformation. This would be a discussion of the thermal regeneration or refinement of the grain which is somewhat outside the subject, but it is considered to be indispensable to define some fundamental notions so as to avoid any confusion or error in the expressions "structure" or "grain."

1. *The Three Structures of Steel.*

Due to its successive passage through the solidification range, the transformation range ($A_3 - A_1$) and the eutectoid or pearlitic transformation (A_1), steel exhibits three superimposed structures:—

(*a*) *Primary dentritic structure* which is formed during *solidification* and which is revealed more particularly by copper reagents that are sensitive to dendritic segregation, that is to say, to the maximum concentration of elements and impurities in the zones which solidify last. This structure is almost insensitive to the usual heat-treatments, so that it can always be found in an unforged casting by means of suitable reagents. At the end of solidification, a grain of the austenitic structure corresponds to each dendrite, but this correspondence ceases after thermal regeneration or forging.

(*b*) *Secondary or austenitic structure* or gamma structure which is formed during the passage through the *transformation range* $A_3 - A_1$ by the separation of the pro-eutectic constituent from the austenite and which is modelled on the grain structure of that austenite, either by separating out at the boundaries of these grains (cellular structure or intergranular distribution) or along the octahedral planes of these grains (intergranular distribution or Widmannstätten structure). This structure depends upon the thermal history above A_3 contrary to the preceding structure.

(*c*) *Tertiary, ferritic or pearlitic structure* or alpha structure which is formed during the *eutectoid or pearlitic transformation* A_1. This structure depends upon the cooling conditions.

2. *Micrographic Grain and Fracture Grain.*

The "grain" of a casting is appreciated either by micrographic examination or by examination of the fracture. These two appreciations may differ because the fracture may follow one of the three preceding structures while the micrographic grain may be included in two different directions.

A—*micrographic grain* may fundamentally denote the actual structure when cold or the austenitic structure which has given rise to it.

A_1—*alpha micrographic grain* or *cold grain*. The grain then defines the crystalline individual of the α constituent, that is to say, the ferrite grain in very mild steels, the "pearlite grain" in hard or eutectic steels (that is to say, the whole of a package of ferrite-cementite plates derived from the same nucleus of crystallisation in the A_1 transformation), and pearlitic areas situated in the ferrite for semi-mild steels.

A_2—*gamma micrographic grain* or *hot grain* is the grain or crystalline individual of the solid gamma or austenite existing above A_3 whence

the cold structure is derived. Under certain conditions of treatment, this cold structure is derived hereditarily therefrom, particularly by the distribution of the pro-eutectoid constituent, and due to this dependence it is possible by examination in the cold to define this gamma grain, to which present practice has given in the case of forged steels more particularly the name of "grain of the steel"; austenitic grain would be preferable, but the use of the expression "grain size" has become common for qualifying it. Furthermore, as this grain is conventionally qualified under the cementation and annealing conditions defined by the MacQuaid-Ehn test, it is directly related only to these conditions and consequently would be more correctly termed "MacQuaid grain."

The cold structure comprises groups of pearlite and ferrite grains derived hereditarily from the same austenitic grain forming a "complex grain" or a cell having elements in common, either the pro-eutectoid envelope (cellular structure) or pro-eutectoid plates passing through the complex grain (Widmannstätten structure).

B. Fracture Grain

Whereas the micrographic attack reveals the various constituents with their volumetric proportions in the steel, irrespective of their mechanical properties, the fracture follows the structure, being influenced not only by the proportion of the constituents, but by their fragility, either specific or crystalline (cleavage), and their continuity throughout the metallic mass. Thus, a constituent in small amounts, but in the form of plates, such as the graphite of cast iron, determines the path of the fracture. A fragile constituent, such as the cementite of hypereutectoid steels, is capable of determining the type of fracture according to its distribution: either intergranular or cellular, producing the granular fracture in the form of small cups having curved faces, or intragranular (Widmannstätten distribution or product of the A_2 transformation), having a fracture with plane, more or less dull facets. Likewise thin, even invisible, films of alumina or inclusions at the boundaries of the solidification grains may determine the surfaces of rupture, even after thermal treatments which upset the structure, provided they have not been dismembered or broken up by forging. There is in that case persistence of the effect of the crude solidification structure, primary structure or "ingotism."

The fracture may also be related to the secondary structure by following the contour of the cells or cleavages, ferrite plates of the complex grains, or with the tertiary structure by following the cleavages of the pearlite or ferrite grains. Intergranular fracture produces cups with more or less dull and curved faces, while fracture by cleavage or intragranular fracture gives plane and brilliant faces. Some authors erroneously refer to the latter as a crystalline fracture.

Thus, the fracture may be entirely or partly related to one of the three structures and to one or other of the two forms just indicated. It will be appreciated therefore that there may be differences between the structures and grain sizes examined by micrography and by fracture. This is shown in particular by the independence, and even the discordance, in the course of the thermal regeneration as appreciated either according to the micrographic grain or according to the fracture grain. The refining of the micrographic grain is generally secured at the end of one or two treatments, while that of the fracture grain is sometimes much more difficult, with persistent heredity of the initial appearance as cast, particularly when aluminium has been added during pouring.

3. Significance of "Grain Size" in Steel Foundry Practice

As has been previously pointed out,[20] there seems to be a fundamental difference in the significance of the MacQuaid Ehn test on forgings and on castings. For forgings, the object is to define the aptitude of the steel to *superheating*, the steel being necessarily initially regenerated by forging, or, more exactly,[21] this test gives a relative indication regarding the situation of the range or temperature of superheating relatively to the selected temperature and duration of the test.

For castings, this test amounts to defining the aptitude of the steel to *regeneration or refinement of the grain by annealing*, the test being then a regeneration annealing complicated by cementation with a view to showing more easily the size of the grain in the carburised region.

There may therefore be concordance or discordance, according to the case. Thus, with the present methods of producing steel, the addition of aluminium tends to refine the MacQuaid grain of forgings, the result of the addition of aluminium being opposed to superheating under these conditions, while in steel castings, the addition of aluminium tends to cause the heredity of the "as-cast" state to persist, that is to say, to oppose regeneration.

Reference should be made to the very interesting experiments of Tadeusz Kuczinski and Josef Glatman on the variation of the size of the solidification grain and austenitic grain with the conditions of solidification of the steel which have been published quite recently (Prace Badawcze Huty Baildon, III, February, 1938, p. 1).

REFERENCES.

15 In this case, the thickness should be less in the vicinity of the walls where solidification is more rapid.
16 This influence of the nuclei is observed in peritectic structures. Greninger (1930) by seeding with copper crystals during solidification a brass having 52 per cent. of copper and determining the orientation of the resulting crystals by means of X-rays, found the following crystallisation, proceeding upward: (1) Crystals of copper introduced; (2) primary α phase of the same orientation as the copper nuclei; (3) coarse β grains having a narrow border of α phase.
17 A. Portevin and R. Castro, Journ. Iron Steel Inst., 1935, **132**, 237; 1936 **134**, 213; 1937, **135**, 223.
18 A. Portevin and R. Castro, Jernkontorets Annaler, 1936, 738.
19 A. Portevin, Bull. A.T.F., 1937, **11**, 65.
20 A. Portevin, International Foundry Congress, Paris, June, 1937 (Bull. A.T.F., July-August, 1937, 314).
21 A. Portevin, "Metal Progress," Nov., 1936, 55.

(*Concluded from next column.*)

Rs. 225 per ton, it is found that a saving of about Rs. 3 per ton of castings produced is effected in the working costs, thus illustrating the advantage of using the ore in place of ferro-manganese wherever the ore is available near at hand.

Further experiments are yet to be conducted to see how far the losses in the cupola may be reduced and to what extent the manganese increase in the cupola iron may be obtained.

Use of Manganese Ore in the Cupola

By B. RAMASESHIAH, B.E. (Superintendent, General Foundry, Mysore Iron and Steel Works, Bhadravati, India).

Whenever higher contents of manganese are desired in castings than could be obtained with the use of the available low manganese irons, it is usual practice to add the necessary quantities of ferro-manganese in the ladle or in the cupola. To eliminate the use of this costly material, the idea was conceived of performing experiments to find out the possibilities of using the manganese ore, which is a very cheap raw material, and get the increased manganese contents by the direct addition of ore in the cupola itself.

In the first experiment, the manganese ore was added on the metal charge in the cupola. The ore was approximately 3 to 4 in. diameter. The Mn pick-up was found to be negligible, being only 0.17 per cent. Most of the material must have been lost in the cupola slag.

In the second experiment the ore was mixed with coke breeze to facilitate reduction, and charged over the coke charges in the cupola, resulting in a better pick-up of Mn.

Experiments on the Use of Manganese Ore in Cupola Melting.

Test No.	Charge. Cwts. Grades. I	II	III	Scotch.	Foundry scrap.	Mn in charge. Per cent.	Mn expected in melt. Per cent.	Mn in sample (av.) Per cent.	Mn in cast ingot mould. Per cent.	Mn pick-up. Per cent.	Expected pick-up.	Limestone in charge. Lbs.	Method of addition of manganese ore.
1	—	—	—	—	32	0.28	1.03	0.61	0.45	0.17	0.22	—	1 cwt. ore charged on 1st charge.
2	—	—	—	—	32	0.28	1.03	0.50	0.63	0.35	0.466	20	56 lbs. ore added over 1st four charges, with addition of 50 lb. coke.
3	—	—	—	—	32	0.28	1.03	—	0.75	0.37	0.493	20	1 cwt. ore charged between 1st and 2nd charges.
4	—	—	—	—	32	0.28	1.03	—	0.54	0.26	0.36	30	1 cwt. ore mixed with 2 baskets of coke breeze with addition of ½ lb. soda-ash and tar to bind. This was packed in C.I. troughs and charged between 1st and 2nd charge.
5	12	10	—	—	10	0.45	1.20	0.63	0.71	0.26	0.36	30	Do. do. do.
6	12	10	—	—	10	0.45	1.20	1.17	0.99	0.54	0.72	30	Alternate layers of ore and coke breeze with small amount of limestone powder put in 2 baskets and placed on bed coke and over this the first charge of iron was charged.
7	—	12	6	4	10	0.42	1.17	0.98	0.86	0.44	0.52	30	As above, but with addition of about ½ lb. soda-ash.
8	—	12	5	4	10	0.42	1.17	0.85	0.88	0.46	0.61	30	Do. do. do.

In every case the weight of manganese ore added was 1 cwt., containing 34.3 per cent. of manganese. A basketful of coke breeze weighs 50 lbs.

In the third experiment, the ore was powdered and mixed with coke breeze and charged between the metal charges. The Mn was found to increase by 0.37 per cent. In the fourth and fifth experiments, the ore was broken in small pieces, mixed with coke breeze and soda-ash and packed in cast-iron containers and charged on the coke charges, but the pick-up was still not found satisfactory.

In the sixth experiment the manganese ore (in the form of small lumps) and coke breeze were arranged in baskets in alternate layers, the quantity of ore for the charge being adjusted so as to allow for about 30 per cent. Mn losses inside the cupola. This time there was an increased pick-up of 0.54 per cent. Mn. The details of the experiments are tabulated and reproduced above.

By using pig-iron containing 0.45 per cent. manganese, the management can obtain molten metal containing 0.99 per cent. of manganese with the use of 70 lbs. of manganese ore per ton of iron charged. The manganese ore used contained 22.5 of iron and 34.3 per cent. of manganese.

By working out costs, taking the present price of ore at Rs. 8 per ton, and of ferro-manganese

(*Concluded in previous column.*)

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The Week's News in Brief

Trade Talk

A COMPLETE DISPLAY of A.R.P. equipment will be shown at the Engineering and Hardware Section of the 1939 British Industries Fair at Castle Bromwich, Birmingham.

EMPLOYEES OF G. & J. Weir, Limited, of Cathcart, Glasgow, have distributed £1,450 from their infirmaries' fund among Glasgow and West of Scotland charitable institutions.

TWO AUSTRALIAN FOUNDRIES, the M. B. John Pty., Limited, of Ballarat, Victoria, and Walkers, Limited, of Maryborough, Queensland, have joined the British Cast Iron Research Association.

THE TOTAL NUMBER of premises on the Team Valley Trading Estate is now 119. Employment in the factories, 76 of which are in production, amounts to 2,135, although few of the factories have yet had time to work up production. Nearly 900 men are employed on estate development and building.

THE 13TH BANQUET of the Lancastria Club—the members of which consists of those who travelled to America in 1926 by the "Lancastria" to participate in an International Foundry Congress—is to be held under the chairmanship of Mr. Frank Russell, F.R.S.A., at the Savoy Hotel, London, on Sunday, December 4.

IT IS EXPECTED that operations will begin almost immediately on the erection of buildings for a metal works at Bridge of Allan (Stirlingshire). The foundry, which is being built on the old gasworks site at Cornton, will be conducted by Cornton Metals, Limited, and it will produce non-ferrous alloys. The directors are Mr. M. C. Dunsmore, Mr. James Davie, Mr. Walter Davie, and Mr. A. C. Dunsmore.

THE GOVERNMENT OF EIRE has made an order imposing a duty of 75 per cent. *ad valorem* (50 per cent. preferential) on plates which bear any inscription or device in the nature of advertisement, direction or notice, and which are made of metal, and have been enamelled in any form or have been painted (excluding advertising cards made of tin), and are not otherwise liable to duty. An open licensing clause is attached to the duty.

IRISH-MADE STANDARDS will in future, so far as is practicable, be used in Dublin's new lighting system. The new lamp standards which have recently been the subject of discussion by the City Council have been obtained from abroad at a cost of £24 each, while the lowest price at which they can be obtained in Eire is £60. The City Manager has stated that an enterprise will soon be in operation in Eire for the production of steel standards.

INCREASE OF MOTOR TRAFFIC makes cast-iron lamp standards dangerous, according to a statement to a sub-committee of Dundee Police and Lighting Committee. The committee decided to purchase 150 steel poles from Birmingham. The public lighting engineer said he had no doubt local foundries would be able to supply cast-iron standards, but they were considered dangerous.

THE NATIONAL "SAFETY FIRST" ASSOCIATION has decided to amend the conditions of the Travelling Safety Scholarship, details of which were recently announced. Originally entry was described as being open to "students of recognised educational institutions" and "articled apprentices." Industrialists have suggested that this would exclude many suitable candidates who are certainly apprentices, but who have not been formally articled. Modification has accordingly been made so that young people in this category will be eligible. The scholarship, made possible by the generosity of Imperial Chemical Industries, Limited, will take the form of a visit to the U.S.A. or Canada, or both, for the study of safety conditions in the summer of 1939.

THE EDUCATION GROUP of the Institution of Mechanical Engineers are to hold a meeting on Friday, November 25, at the Institution, Storey's Gate, Westminster, S.W.1, at 6.30 p.m., when Mr. J. G. Pearce (Director of the British Cast Iron Research Association) will speak on "Training for the Foundry." An informal discussion will follow. As the meeting is of an informal character, no advance copies of Mr. Pearce's remarks are available, but a summary of the discussion may be published by the Institution subsequently. Members of the Institute of British Foundrymen are cordially invited to attend the meeting, and also to be present at an informal supper, following the meeting, at St. Stephen's Restaurant. Those wishing to attend the supper are asked to inform the secretary of the Institution.

Personal

MAJOR-GENERAL B. C. FREYBERG, V.C., has been appointed a director of the Birmingham Small Arms Company, Limited.

MR. H. K. NEWCOMBE has been appointed an additional director of Barton & Sons (1935), Limited, makers of electric conduits and fittings.

MR. A. M. STEPHEN, chairman of Alexander Stephen & Sons, Limited, is the new President of the Shipbuilding Employers' Federation.

Wills

RUSSELL, WILLIAM, of Stockton-on-Tees, ironfounder	£16,636
BROWN, R. S., of Sheffield, retired steelworks manager	£7,734

Obituary

THE DEATH has occurred of Mr. John Cameron, proprietor of the Cameron Foundry, Glasgow. Mr. Cameron, who was for some years employed by Smith & Wellstood, Limited, as a salesman and traveller, commenced business on his own account between 30 and 40 years ago. His business consisted chiefly of the manufacture and sale of house stoves, ranges and grates. Mr. Cameron was a former President of the Iron, Steel and Ironmongery Benevolent Association of Scotland.

MR. JOHN BELLISS died in Birmingham on November 9, aged 71. Mr. Belliss occupied a prominent position in the engineering industry. A son of the late John F. Belliss, of Birmingham, he served an apprenticeship as an engineer with his uncle, Mr. G. E. Belliss, of G. E. Belliss & Company (now Belliss & Morcom, Limited). He was appointed a director of Belliss & Morcom in 1915. He was a member of the Council of the Institution of Mechanical Engineers, chairman of the Midland branch in 1934-35, and president of the Birmingham Association of Mechanical Engineers for two years. He was a former president of the Birmingham Chamber of Commerce, and for some years was a member of the Management Committee of the British Industries Fair.

Company Reports

International Nickel Company of Canada, Limited.—Quarterly dividend of 50 cents a share.

Atlas Steel Foundry & Engineering Company, Limited.—Final dividend of 15 per cent. and a bonus of 10 per cent., making 35 per cent. for the year.

Crabtree Electrical Industries, Limited.—Net revenue for the year ended October 31, £91,204; brought in, £17,396; dividend of 10 per cent., plus 7½ per cent. cash bonus, on the ordinary shares; carried forward, £18,819.

Heenan & Froude, Limited.—Net profit for year to August 31, £46,891; brought in, £16,946; dividend of 10 per cent. and a bonus of 2½ per cent.; tax provision, £10,500; to staff fund, £2,317; to general reserve, £13,828; carried forward, £16,520.

John I. Thornycroft & Company, Limited.—Net profit for the year ended July 31, £160,006; brought in, £44,200; dividend on the ordinary shares of 8 per cent., £24,000; dividends on the preference and preferred ordinary shares, £30,750; to special reserve, £50,000; to reserve account, £50,000; to benevolent fund, £4,000; carried forward, £45,456.

John Williams & Sons (Cardiff), Limited.—Profit for the year ending September 30, after providing for income tax, bad debts and general depreciation, £20,870; brought in, £7,910; half-year's dividend on the preference shares (free of tax) and 5 per cent. interim dividend on the ordinary shares (free of tax), £4,550; half-year's preference dividend to September 30, £750; final dividend on the ordinary shares of 7½ per cent. (free of tax), £5,700; bonus to staff and provision for pension scheme, £3,000; depreciation of machinery and buildings, £5,000; to general reserve, £1,000; carried forward, £8,780. Meeting, December 1.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

491,914. SERVAIS, F. J. J. Barbed wire, and method of producing the same.

491,921. BASSET, L. P. Process and apparatus for the simultaneous manufacture in a rotary furnace of iron or steel, and Portland cement, or hydraulic lime.

492,026. KRAMER, W. Apparatus for making welded wire netting.

492,031. ECCLESTON, J. H., and HART, H. Method of and machine for manufacturing fine wires having a reduced diameter portion between the ends.

492,066. SERCK RADIATORS, LIMITED, and ZIMMERMANN, H. J. Tanks for containing liquids used in the quenching of heat-treated metal articles.

492,071. BRITISH INSULATED CABLES, LIMITED, and PACKER, J. L. Manufacture of tubes.

492,088. BRITISH THOMSON-HOUSTON COMPANY, LIMITED. Methods of joining metals.

492,089. JULIEN, J. D. Method of and means for altering the physical structure of metals by mechanical treatment.

492,212. VANADIUM CORPORATION OF AMERICA. Extraction of vanadium from vanadium-bearing material.

492,216. VEREINIGTE LEICHTMETALLWERKE GES. Apparatus for casting metal ingots.

492,230. METAL TRIM, LIMITED, and PENKOLA, E. Production of cold-rolled profiled sections from metal strip.

492,240. BUDERUS'SCHE EISENWERKE. Machine for manufacturing metal tubes by the centrifugal casting method.

492,266 ELIAN, J. Method for preparing iron and steel.

492,445. GILBERT, W. V., and MAGNESIUM ELEKTRON, LIMITED. Protection of metals against corrosion.

492,454. DEUTSCHE EISENWERKE AKT.-GES. Centrifugal moulds.

492,520. WILLIAMS, G. Alloy-iron castings for the manufacture of piston-rings, cylinder-liners, and the like.

492,521. BECKER, G., and STEINBERG, F. Formation of protective layers on iron and steel articles.

492,564. SIEMENS & HALSKE AKT.-GES. Devices for tilting high-frequency furnaces.

492,638. WILSON, P. H., and STANTON IRONWORKS COMPANY, LIMITED. Pipe joints.

Forthcoming Events

NOVEMBER 25.

Institute of Metals (London Branch):—Supper-dance, at Thames House Restaurant, Millbank, London, at 7.30 p.m.

Manchester Association of Engineers:—"Human Factor in Industry," Paper by A. P. Young, O.B.E., at Engineers' Club, Manchester, at 7.15 p.m.

Institute of British Foundrymen

NOVEMBER 25 AND 26.

London and Sheffield Branches:—Joint meeting in London. On November 25, visit to Sterling Manufacturing Company's works, Cubitt Town, at 2.30 p.m., and informal dinner at London Tavern, Fenchurch Street, at 7 p.m. On November 26, exchange of Papers, at Charing Cross Hotel, at 10 a.m.

NOVEMBER 25.

Middlesbrough Branch:—Reception and dance, at Linthorpe Assembly Rooms, Middlesbrough, at 7 p.m.

NOVEMBER 26.

Newcastle-upon-Tyne Branch:—"A Chemist Looks at the Foundry," Paper by J. Stott, at Neville Hall, Newcastle-upon-Tyne, at 6.15 p.m.

The Institute of Vitreous Enamellers

NOVEMBER 21.

Works Visit:—To Darwins, Limited, Fitzwilliam Works, Sheffield. (The company has kindly extended an invitation to the visitors to luncheon.) Assemble at main gates at 12.30 p.m.

NOVEMBER 24.

Scottish Section:—"American Practice—Some Impressions from the Tour," Paper by J. Jackson, at Royal Technical College, Glasgow, at 7.30 p.m.

ONCE more the Season of Good Will draws nigh and though we would be loth to interrupt your thoughts of the festivities to come, we feel that in your own interests we must remind you that now is the time to order your supplies of Firebricks, Silica Bricks and Basic Bricks, etc., for your Christmas Repairs. Orders placed at once can be executed in time for Christmas, enabling you to avoid the delay and disappointment which so often accompanies last-minute demands for supplies.

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Raw Material Markets

Delivery specifications continue to increase and contracts are being gradually liquidated. Producers of pig-iron are now making arrangements to bring into operation blast furnaces which have been idle for a considerable time. New business is still on a hand-to-mouth basis and forward contracts will not be entered into until it is known what quotations will rule after the turn of the year. An early decision in this respect is anticipated. Similar conditions prevail in the steel trade and the needs of many consumers for rearmament purposes are substantial.

Pig-Iron

MIDDLESBROUGH.—Makers of pig-iron in this area are expecting quite a rush of new orders as soon as future prices are fixed. Consumers' stocks are being steadily diminished and it is anticipated that they will desire to replenish their supplies. As yet, several users have still quite large tonnages to take up under existing contracts, but specifications have recently been greatly increased. A disappointing feature of the trade is the lack of export inquiries.

A quickening of activity is also noticeable among consumers of hematite and the call for deliveries is much better than has been the case for many months. Consumption has now overtaken production, but makers have substantial supplies in stock and the need for increasing outputs is not yet urgent. However, two stacks at the Ayresome Ironworks have recently been relighted. It is hoped that under the stimulus of the rearmament programme the demand for hematite will continue to expand and forward contracts are likely to be entered into by some consumers when prices for delivery next year are announced.

LANCASHIRE.—While the outlook in this district is much brighter, the improvement is by no means universal and some sections are still badly placed with regard to business. Of these, light-castings makers and textile machinists are the worst off, while several jobbing founders are also in the position to accept much more business. On the other hand, many of the speciality concerns are well situated and existing orders will ensure a good rate of activity for many months. For delivery up to the end of the year in the Lancashire price zone, Derbyshire and Staffordshire brands of No. 3 foundry iron are quoted on the basis of 114s., with Northamptonshire No. 3 at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of consumer. Hematite is in rather better demand, but the call for supplies is still disappointing.

MIDLANDS.—Immediate needs only are being satisfied in high-phosphorus pig-iron and consumers whose stocks are low are awaiting the publication of next year's prices before committing themselves further. Consumers are hoping that substantial reductions will be made in quotations, but some doubt still exists as to the trend of future prices. Low-phosphorus iron is still being taken up in large tonnages, especially by the heavy engineers. Prices of this material are not controlled and vary from £5 10s. to £6 10s., delivered, according to the source of supply. The improvement in the hematite trade is restricted to a better call for deliveries under contracts and few new orders can be expected for some time, as stocks at the consumers' works are quite heavy.

SCOTLAND.—The production of 11 blast furnaces is still more than sufficient to meet the current requirements of consumers, but deliveries are being taken up more freely. If prices are reduced at the end of the year some new orders are likely to be placed, but many consumers are sceptical that any lower quotations will rule after December 31. Meanwhile, business is confined to small parcels for early delivery. The local steelworks are moderately well employed, but they have adequate tonnages of pig-iron on hand and are not interested in new contracts at the present time. Quotations for steel-making irons are as follow:—Hematite mixed numbers, 133s.; Scottish basic, 107s. 6d.; English and Indian basic, 100s., all delivered f.o.t. steelworks.

Coke

The demand for foundry coke has been well maintained and some ovens are having the utmost difficulty in keeping abreast with orders. Prices are firm, with no possibility of any early reduction. For delivery to Birmingham and Black Country stations, best Durham foundry coke is quoted at 50s. 6d., with Welsh coke at a minimum of that figure.

Steel

Moderately active conditions have continued to rule in the steel market, and the brighter tone noticed recently has been well maintained. Most of the buying, however, is still limited to small parcels intended to carry consumers over until the end of the year and there has been comparatively little forward contracting. In the semi-finished steel section of the market, business is on the quiet side, although the demand is more active than for some time past. As a result of recent buying the mills producing this class of steel have a good tonnage of orders in hand, and production appears to be increasing. The stocks of foreign semi-finished steel at consumers' works have been materially reduced and this has given the market a more confident appearance. The market for finished steel is fairly active, but somewhat irregular. There is a fair demand for structural steel, but the dearth of new shipbuilding orders has been severely felt by the steel industry. The export trade continues quiet, but shows signs of expanding.

Scrap

Cast-iron scrap continues to be the most active feature of the market and the turnover in all districts is quite satisfactory. Steel scrap, however, continues to be weak. Most consumers are in possession of stocks which will last them for a considerable time. There has been little improvement in the demand for scrap from the steelworks.

Metals

Copper.—Although there has been only a moderate amount of consumptive buying during the past few days, the tone of this market has been quite firm. The October statistics, referred to below, make a satisfactory showing, while the further depreciation in sterling against the dollar also has had the effect of strengthening the market. Prices eased on Monday and the copper market, in common with other non-ferrous metals, became rather depressed. Elections have caused the American market to be rather subdued, but the outlook for industry is satisfactory.

The American Copper Institute reports that world stocks of refined copper fell by 32,000 short tons during the month of October; stocks now total 425,000 tons. While consumption in the United States rose during the month by 16,000 tons, consumption in the rest of the world was 7,000 tons lower on the month. World refined output was 13,000 tons higher at 167,000 tons, the United States accounting for 11,000 tons of this increase. Of the world stock of 425,000 tons, 267,000 tons is in the United States and 158,000 tons elsewhere. The month's statistics are generally regarded as satisfactory, but copper circles in America had hoped for a greater reduction of stocks of refined metal.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £46 13s. 9d. to £46 15s.; Friday, £46 15s. to £46 16s. 3d.; Monday, £46 6s. 3d. to £46 7s. 6d.; Tuesday, £45 6s. 3d. to £45 7s. 6d.; Wednesday, £45 16s. 3d. to £45 18s. 9d.

Three Months.—Thursday, £46 18s. 9d. to £47; Friday, £46 18s. 9d. to £47; Monday, £46 10s. to £46 11s. 3d.; Tuesday, £45 11s. 3d. to £45 12s. 6d.; Wednesday, £46 to £46 2s. 6d.

Tin.—A firm tone has continued to prevail in this market and on Monday the price touched a new high level for the year, the turnover on that day being 675 tons. Business in this country has not been particularly interesting, on the whole, but America has been in the market for quite substantial tonnages, while Japan continues to take up supplies on a good scale. A meeting of the International Tin Committee will be held on Tuesday next and a decision as to the quota for the ensuing quarter will be made. The present rate of output is 45 per cent. of standard tonnages, of which 10 per cent. is diverted to the buffer pool. It may be regarded as certain that no reduction will be made in this quota, while it appears probable that a small increase will be decided upon.

Official quotations were as follow:—

Cash.—Thursday, £214 5s. to £214 10s.; Friday, £214 5s. to £214 10s.; Monday, £216 5s. to £216 15s.; Tuesday, £215 5s. to £215 10s.; Wednesday, £215 5s. to £215 10s.

Three Months.—Thursday, £214 15s. to £215; Friday, £215 2s. 6d. to £215 7s. 6d.; Monday, £216 15s. to £217; Tuesday, £215 15s. to £216; Wednesday, £216 to £216 2s. 6d.

Spelter.—The import duty question has still to be settled and until this has been done little buying is likely to take place. Also, the revival of the International Zinc Cartel is still more than a possibility, although it is not expected that any early announcement will be made. Here, again, the result of the import duty discussions is awaited.

Daily market prices:—

Ordinary.—Thursday, £14 15s.; Friday, £14 13s. 9d.; Monday, £14 12s. 6d.; Tuesday, £14 7s. 6d.; Wednesday, £14 7s. 6d.

Lead.—Business in this country has not been very brisk recently, but Continental and Japanese demands are reported to be active and large tonnages have changed hands. At home, makers of armaments are busy and their lead requirements are quite heavy, but other consumers are not well situated.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £16 5s.; Friday, £16 2s. 6d.; Monday, £16 5s.; Tuesday, £16; Wednesday, £15 18s. 9d.

Scrap.—On the whole, rather a dull tone has prevailed and the demand for non-ferrous scrap has not been very active. Certain descriptions of aluminium scrap have been taken up on a much better scale, while gunmetal and phosphor bronze are in good demand.

Approximate selling prices for old metal:—New aluminium cuttings, £70; rolled, £53; cast, £29; foil, £80. Copper, £39 to £45; braziery, £34 to £35. Brass (clean), £21 to £24. Zinc, £11. Lead, £15. Gunmetal, £40 to £42.

Contracts Open

Belfast, November 28.—Iron castings, malleable iron and steel, etc., for the Belfast Harbour Commissioners. Mr. M. J. Watkins, general manager, Harbour Office, Belfast.

Bridlington, November 19.—Provision and laying of 830 yards of 3-in. water mains and fittings, and the construction of sewers, etc., for the Rural District Council. Fairbank & Son, civil engineers, Barclay's Bank Chambers, St. Helens Square, York.

Felling-on-Tyne, November 19.—Cast-iron work for twelve months, for the Urban District Council. Mr. T. Myrddin Baker, clerk, Council Buildings, Felling-on-Tyne.

Leicester, December 3.—Supplying and laying 3,400 yds. of 15-in. dia. cast-iron rising main, for the Corporation. Mr. A. T. Gooseman, city engineer, Town Hall, Leicester. (Fee £2, returnable.)

London, November 21.—Spun-iron pipes and cast-iron pipes and specials, for the Metropolitan Water Board. The Chief Engineer (Room 171), 173, Rosebery Avenue, E.C.1.

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